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THE MISSOURI RIVER.*

BY GEORGE S. MORISON, C. E.

WHEN I was asked to speak to you, I said that I had not time to prepare a lecture, but that I would try to give you an informal talk on some subjects which might be of interest; and after thinking it over I concluded that instead of wandering around very much I would content myself with about three thousand miles and talk to you about the Missouri River.

Those of you who have lived in the West, and I suppose there are some such among you, know that the Missouri River belongs to a class of streams totally unlike those of the eastern part of the country. The Missouri River is essentially and preëminently a silt-bearing river, and that is what gives it all its peculiar features. In the eastern part of the country it is customary to think of a river as a running stream of comparatively clear water, and this is the character of most of the rivers in New York State; but the principal rivers of the world are of a totally different character; they are not clear water at all, they are silt bearers. They are apparently muddy, but the mud is the silt which they are carrying down. A clear water river has, so to speak, but one function; its

* One of a course of lectures delivered to the students of the School of Mines, Columbia College, under the auspices of the Department of Civil Engineering. The lecture was given Wednesday, March 27, 1895.

business is to drain the surrounding country and to carry away the water which is produced by rainfalls. A silt bearer performs a double duty; it not only carries away the drainage of the country through which it runs, but it also carries off a great deal of the country at the same time. If the soil is composed largely of gravel or granite, and thus is heavy and not easily washed, a river carries off nothing but water; but if the soil is of a lighter character, easily washed by water, very rapidly turned into mud and that mud of varying consistency according to the amount of water which it holds, water running over such a country will wash away a portion of the soil and produce silt-bearing rivers. Such rivers carry a great deal of silt, which is simply a finely subdivided soil mixed up in the water, and when that water moves at any considerable velocity the silt is, so far as motion is concerned, dissolved in it. The amount of silt which any river can carry varies with the velocity of the current; the greater the velocity the more the silt that the river can carry, so that whenever the velocity is decreased, the silt must be dropped. Hence it is impossible to have broad lagoons or lakes or anything of that kind in a silt-bearing river. As soon as any portion of the current becomes slack the silt begins to drop, and the result is that the bottom of the river is raised, and continues rising until the silt actually reaches the surface of the river, and a lagoon is therefore impossible; it can only exist in the form of the dropped silt, or, in other words, in the form of a sand bar; and that is one of the features of the Missouri River.

Whenever the current slackens the silt is dropped, and one can almost measure the height of the last flood by seeing the height of the new sand bars. On the whole length of the Missouri River there is nothing like a lake or a lagoon. There are lakes in the valley, but they are caused in an entirely different way, which I will describe presently. It is, perhaps, from this feature that the Missouri, which is really the main artery of the Mississippi, has always been treated as a branch. The upper Mississippi is a clear water river; it is not a silt bearer. Where the two rivers come together, at high water the Missouri is the great river, although the Mississippi is the greater at low water. The Mississippi, practically, without much current, is still a broad sheet of smooth, clear water; the Missouri at low water is nothing but a narrow channel running through a great sand pile, and that led to its escaping the notice of the first explorers, who, when they passed a great sand bar fif-

teen miles above St. Louis, had no idea that it was really a great river.

The Mississippi River, as I shall try to show from this map before you (which is principally distinguished by the things left out), is formed by four great rivers. The first of these is the Tennessee River, which, rising in East Tennessee, comes down through Alabama, Tennessee and Kentucky and joins the Ohio at Paducah. The Cumberland River, of comparatively small size, enters the Ohio just above the mouth of the Tennessee; the result is, that where the two rivers, the Tennessee and the Ohio, come together, the Ohio River is the larger of the two; if, however, the Cumberland had entered the Tennessee, instead of the Ohio, the Tennessee would have been the larger of the two where they come together. The Ohio, whose sources reach into New York State, although they are principally farther south, unites with the Tennessee at Paducah, which may practically be taken as the upper limit of the alluvial delta of the Mississippi, and the Ohio and Tennessee, united into one river, join the Mississippi at Cairo. Where the Ohio and Mississippi come together, the two rivers are of about equal magnitude and totally different characteristics. Both the Tennessee and Ohio, coming through a mountainous country, are subject to extreme floods, but they are rivers of very stable character, and they carry very little silt. The Mississippi, where it is joined by the Ohio, is a great silt bearer, and the silt-bearing Mississippi gives the features and establishes the characteristics of the river from Cairo to the Gulf. The upper Mississippi is a less important river in its discharge and general physical characteristics than either the Tennessee or the Ohio; it rises in a country which is comparatively flat and full of small lakes; there is a point in Minnesota where the Red River of the North and the Minnesota head together; they rise in a single swamp, and a moderate sized dam would permanently turn the water either towards the north or towards the south. The Minnesota, running southerly, joins the Mississippi at Fort Snelling; it is now an insignificant river, but the valley is the valley of a great river; this is explained on the theory and by the geological fact that at one time evidences show that the Saskatchewan, which discharges into Lake Winnepeg, found its outlet southward instead of northward, where at present it finds its way through the Nelson River into Hudson Bay; when the outlet of Lake Winnepeg was southward, this

very flat country now drained by the Red River of the North all drained southward, and in those days the upper Mississippi was a great river; but as it is now, rising in the lakes of Minnesota, in a country which is largely sandy, and to some extent a granite country, and having an easy fall, it is a clear river which carries practically no silt and plays but a small part in the physical action of the Mississippi River below the Missouri.

The Missouri is the real source of the Mississippi, not only in its length but in the physical characteristics of the whole river below its mouth. In the northwestern corner of Wyoming is located the Yellowstone National Park. This park is really the summit of the continent and at this summit five different rivers take their source; the Madison, Jefferson and Gallatin unite to form the Missouri River; the Yellowstone River, rising nearly in the same vicinity, comes down and joins the Missouri; the Snake River, rising in the same neighborhood, passes down to the boundary between Washington and Oregon; a river known by several names in its infancy and then called Clark's Fork, runs across the international boundary, and comes back as the Columbia River and finally unites with the Snake and passing westward discharges into the Pacific; this stream is a great and magnificent river, but is not a silt bearer. The two upper branches were called at one time Clark's Fork and Lewis's Fork, being named from Lewis and Clark, the explorers; the name of Clark's Fork is still retained, but unfortunately Lewis's Fork has become the Snake, which is a rather ignominious change. At the same point rises the Green River, which, flowing southward, becomes the Grand River, then the Colorado, and flowing through the Grand Cañon passes down to the Gulf of California. We have from this summit of the continent five individual rivers and three systems of rivers taking their origin, and leading in different directions. All these rivers are practically the same where they begin; they are all the kind of rivers that are found in a mountainous country, showing clear water running rapidly, filled with fish until they are fished out and the kind of rivers which people expect to find. The rivers flowing to the west go through a mountainous country and a soil which does not tend to produce silt, and they remain clear water rivers, the Columbia being especially so because of the number of lakes which form settling basins for it. These rivers cutting right through the mountains pass out to the Pacific as clear

water streams, the Columbia going through a gap which is practically at tide level, being but 100 feet above it.

The rivers that run to the east all start in the same way, but their courses pass through a section of country known as the Bad Lands. That country receives comparatively little rainfall, but is composed of soil which is very rapidly disintegrated by air, and when it has been disintegrated is very easily washed away by water; with the peculiar conditions of that climate it has abundant opportunity to air-slack and turn, as it were, into dust during the late summer and fall months, and to be washed away in the spring. This is the source of the silt of the Missouri, and while both the Yellowstone and Missouri start as perfectly clear mountain streams when they pass out from Montana, they have become absolute silt bearers. When the Yellowstone first passes out of the Cañon it has a gravel bottom. The gravel is found all the way down, but this gravel soon begins to be overlaid by a soft silt, and the layers of silt increase until the gravel is twenty feet or more under them. In the same way the Green River passes through a country similar to the Bad Lands, then through the great Cañon of the Colorado, which has many of the same features, and coming down in the neighborhood of Fort Yuma is also a silt bearer; but we have not to do with it.

The Missouri River, from its point of junction with the Yellowstone down to its mouth, is everywhere a bearer of silt, which is brought down to be dropped in every low-water season, picked up in every high-water season, and finally carried to the Gulf. The river below the mouth of the Missouri is of the same character, but as it has the same source of supply of silt, and has its water supply doubled from the Ohio River and increased by other tributaries, the amount of silt to unit of water is decreased. The velocity of the river is less, and, though all the same actions take place on the lower Mississippi that take place on the Missouri, they are on a larger scale and take place more gradually. As I have sometimes expressed it, the Missouri River is a great contractor; it took the contract many centuries ago to build the State of Louisiana. It was given a borrow-pit near its source, and it has brought more than half the State of Louisiana from that borrow-pit in Montana. This has been the duty of the river, and if it had not run through the Bad Lands the productive sugar regions of Louisiana would never have existed. That process is still continued; the Missis-

sippi River advances roughly a foot a day into the Gulf, and the material on which its advance depends is brought from Montana.

Whenever a silt bearing river overflows its banks the current outside their limits shortly becomes slack and the result is an immediate deposit of silt along each side of the river; on the Missouri, as on all silt-bearing rivers, the ground between the bluffs which limit the bottom land is always highest next to the water. The bottom lands always slope from the river towards the bluffs, and when we get down to the lower Mississippi where there are no bluffs we come to the condition which everyone knows about in Lousiana, where the highest ground is near the river. It used to be said that there was one hill in Louisiana and the Mississippi River ran on top of it, although that expression is not correct. The surface of the Mississippi River is higher than the surrounding country, but the bottom of the Mississippi River is considerably lower, so that though the Mississippi can slop over, it cannot all run out on the surrounding country.

While the Mississippi and the Missouri are the silt-bearing rivers with which we are most likely to have to do, they are not by any means the only silt-bearing rivers. The principal rivers of the world (perhaps it is not too much to say) are silt bearers. We all know of the work that the Nile has done as a silt bearer; that it has made the whole alluvial plain of Egypt, which country would have been absolutely impossible without the Nile. The Ganges is throughout a silt-bearing river with many of the same features possessed by the Mississippi, and I may perhaps mention a little thing which it is well to remember, that the mouth of the Ganges is almost exactly opposite the mouth of the Mississippi; one is in longitude 90° east and the other is in longitude 90° west.

Perhaps the most striking example of silt-bearing rivers is the Yellow River of China, which passing through beds of loess in western China carries down an enormous amount of silt. This river flows through a country which for thousands of years has been densely populated and the river has been leveed and kept within its levees most of the time, so that its deposits have been confined within those limits and have not been allowed to raise the surrounding country. The river thus actually does what the Mississippi does not; it runs on top of a hill; not merely the surface of the river but the bottom of the river is above the adjacent country, so that when the banks break the whole river runs

out. That is the explanation of the terrible floods which at long intervals and sometimes more frequently have characterized the Yellow River.

The Missouri, after it has once been fairly formed by the junction of the Yellowstone, passes down through the two Dakotas, generally with a bottom land about two miles wide, although there is a portion of this part of its course where it is comparatively narrow. It has several lesser tributaries and finally, below Omaha, it is joined by the Platte River, a stream of an entirely different character, carrying a great deal of sand; it has been termed a sand choked river, but it is not a silt bearer. It is again joined at Kansas City by the Kaw River, spelled Kansas, which is a prairie river with no special features. In passing through Missouri it is joined by several streams of considerable importance, none of which can be said to do anything more than contribute water, though some of them bring in enough sand during the flood season to have considerable effect on the under portion of the alluvial deposit.

The Missouri is usually subject to three floods. The first comes in February and is not very important; it is seldom observed above the mouth of the Kaw, and is due principally to winter rains. The next comes in April, and it was formerly thought that the April flood came from the Platte; but a better understanding of the country shows that it has an entirely different origin. The April flood is due to the ice breaking up in the upper Missouri, and going out. If a river flows from north to south it usually happens that the ice goes out in the lower portion of the river first, thus gradually wearing away and moving out from above so that it creates no special floods. If a river flows from south to north the ice breaks up in the upper portion of the river first, while the lower portion is still closed and the result is that the ice coming down from above packs against the ice that has not yet moved and forms a series of dams which are known as ice gorges, and which hold the water back until they are broken; the flood then moves down until another gorge is formed and the whole thing is repeated. I understand that this is the case on the Siberian rivers, which are subject to terrible floods in the spring months. If a river flows from east to west its manner of breaking up will depend somewhat on the climatic conditions. As a rule the Missouri flows from west to east and then from north to south; the river

generally opens from the mouth upwards, for a considerable portion of its length, and then opens from the source down, over the remainder of its course. The ice below the northern end of Iowa usually goes out without much disturbance, but above this an ice gorge will sometimes be formed in the river, which will suddenly raise the water from ten to thirty feet, and when this gorge breaks it will be succeeded by another gorge below and so on, yielding successive floods until it reaches the point where the river is clear; the flood then travels down the river, the water gradually becoming lower as it passes down. It is the same kind of action as that which occurred in Pennsylvania when the city of Johnstown was destroyed by the bursting of a reservoir in the mountains; but this is a natural reservoir, which can be expected to break every year. The most remarkable instance of this kind that has ever been known took place in 1881, when the ice gorges formed as usual up toward the source, but the river remained closed down to the neighborhood of Yankton; the result was that a series of gorges occurred, each of them a little worse than the one before it, until finally the largest gorge broke near Yankton and let the flood down the valley and made by far the worst flood of which there is any record. Above Kansas City it was a higher flood than had ever been known; in the next reach of river it was a higher flood than has been known since that time, but in the lower portion the floods of 1883 and 1892 were both higher than the flood of 1881. In the following year an ice gorge formed at Fort Stevenson and raised the river higher than it was raised in 1881, and maintained it in that condition until it was clear all the way up to Fort Stevenson; the result was that there was no special flood in the river below. The flood therefore that comes in April always has this origin, and whenever the river is known to be clear pretty well up its course, the people on the lower river may know that they are safe from flood. The June flood has a different origin; it used to be supposed that this later flood was due to the melting snow in the mountains, and that undoubtedly does begin it; but it is really due to the fact that the rainy season of a large section of country through which this river flows, is in May and June. For that reason we get floods in this river as well as in the Colorado and all other rivers whose origin is the same, during the month of June. On the lower Missouri the flood generally culminates about the first of July and it has happened at times

that the fall of rain on its lower section of the river, where the annual rainfall is several times what it is higher up, is enough to make very high water without much assistance from the upper river. The flood of 1892, which was an extraordinary one, was caused entirely by rains along the lower river.

One result of this order of floods is that the Missouri River is a safe stream to work in during the fall months, and it would be safe in winter if it were not for the ice; work may be done very safely in the Missouri River during the second half of the year.

One of the features of a river of this kind is that as its banks are generally level and made of deposited silt, which is part of the material that the Missouri is using to build Louisiana, that silt must constantly be picked up and moved on; at one point I had occasion to watch the river for several years; it was regularly fifty feet deep on the 1st of July and about fifteen feet deep on the 1st of January, and the surface of the water was perhaps ten feet higher in July than in January; when the river began to rise it began to scour out its

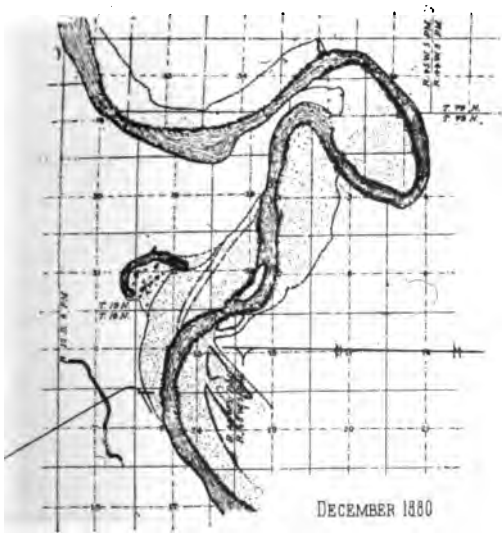

FIG. 1.—The Missouri River opposite Blair Crossing, December, 1880.

bottom; in the April flood, which comes very rapidly as floods from breaking dams must, it did not have time to scour very much, so that the flood was apparently larger than it really was. The June flood, which comes slowly, has time to scour out the bot-

tom, so that though in the June flood the height of the water may not be as great as in the April flood the rate of discharge is very much greater. When the flood has passed its limit the surface falls and the section of the river is reduced; the current gradually slackens and the depositing action of the silt in the channel begins. By the 1st of October, perhaps by the 1st of September, the river will come down pretty nearly to low water, but comparatively little of the filling action will have occurred and the river bed will not have changed much. The silting action will then go on through the fall months until the section is reduced to a very small fraction of what it was before. As those changes in the river caused by the action of silt are the principal features which I want to call your attention to, we will now pass on to the views.

At Blair Crossing, Nebraska, in July, 1879, the Missouri River was high and the current strong. The cutting in progress was strongly indicated by the effects upon the shore lines. Three years later I was asked to examine the location with reference to bridging the river. You will observe on the map Fig. 1, showing the river one year later that it had cut in at one place so

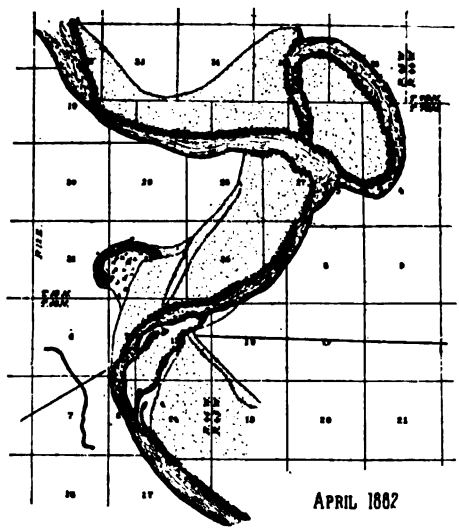

FIG. 2.—The Missouri River opposite Blair Crossing, April, 1882.

as to leave a very small neck of land; in the spring of the next year it had cut that neck completely off and had left the old channel which then became a lake, Fig. 2. This is the only

way in which lakes are formed along the Missouri. The neck was cut off all at once and as the water had ceased to run around it no more silt could be dropped and the water gradually shut off the lake, which is a constant occurrence on the Mississippi River. I determined that although the river was practically about 7,000 feet wide, only a length of bridge sufficient to pass the water was required. I therefore built a dike to confine the flow of water and protected the banks from erosion by rock, and then

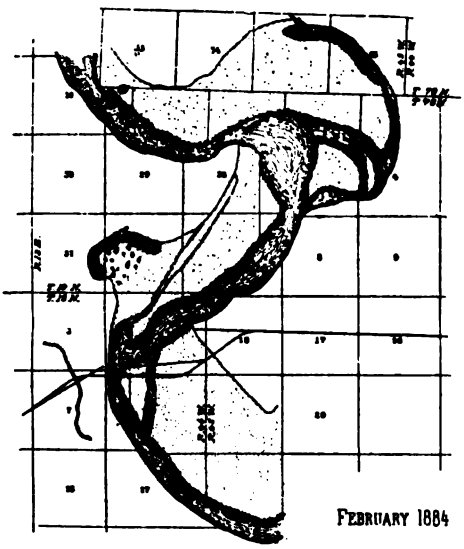

FIG. 3.—The Missouri River opposite Blair Crossing, February, 1884.

built the bridge on the location shown. Before the completion of the work in February 1884, the ice went out with considerable violence, came down over the bar and swept out the trestle work which formed the east approach, but the dike had done its work and the disused channel disappeared entirely. The trestle was replaced, and subsequently filled, so that the condition a year later was as shown in Fig. 4. The next view* exhibits the government survey of 1890 with the bridge and dike in place. The protected banks are secure, but the river has gradually formed the great sand bar above the bridge. The protection work is still kept up, and the bridge, only 1,000 feet long, is really longer than is necessary to cross the river. The sand bar is now covered with willows, yet in

*Not reproduced.

time the river will probably repeat its former course and make some more cut-offs, but so long as it is held at the points selected the bridge is all right.

Coming down now to Nebraska City, which is about 50 miles below Omaha, the view before you, Fig. 5, shows the condition of the river in 1879. The railroad, the Kansas City, St. Joseph and Council Bluffs, now occupying the location shown has occupied several different locations which the river has compelled. The main line of the railroad passes around, so as to necessitate a

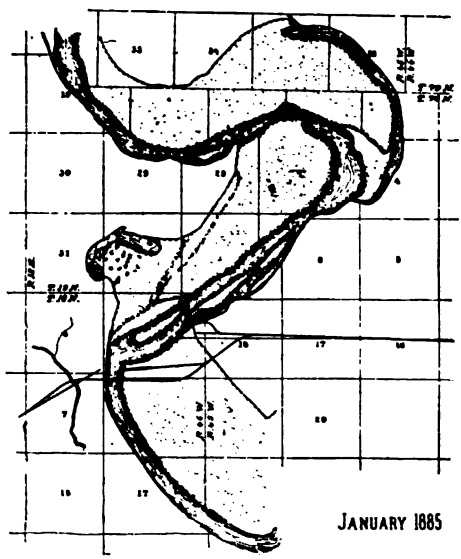

FIG. 4.—The Missouri River opposite Blair Crossing, January, 1888.

branch to accommodate Nebraska City. Nebraska City Island was shown on the government maps as a part of the State of Nebraska; in the winter of 1886–7, an ice gorge formed in the main channel on the east side of the island; it was not an important gorge but simply a local one; yet it forced the water to go through the smaller channel, which consequently became enlarged, and when the water went down the main channel was between Nebraska City Island and the Nebraska shore (Fig. 6); the old channel, however, remained. At that time I was asked to look into the situation, with a view to building a bridge or at least to maintaining a ferry. I decided that we must close the east channel entirely and con-

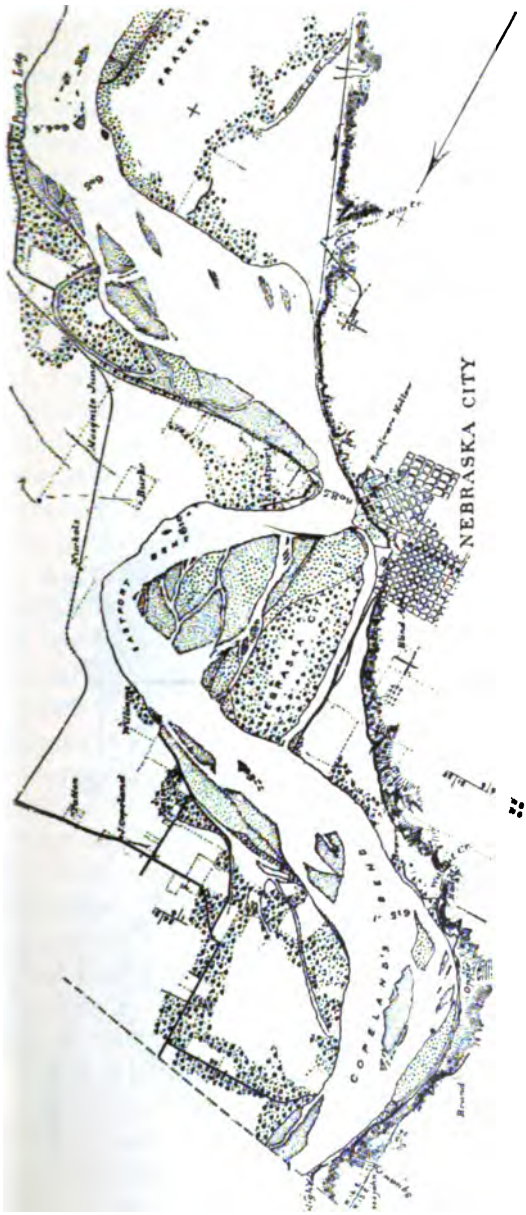

FIG. 5.—The Missouri River opposite Nebraska City in 1879. The east bank is in Iowa; the west bank in Nebraska.

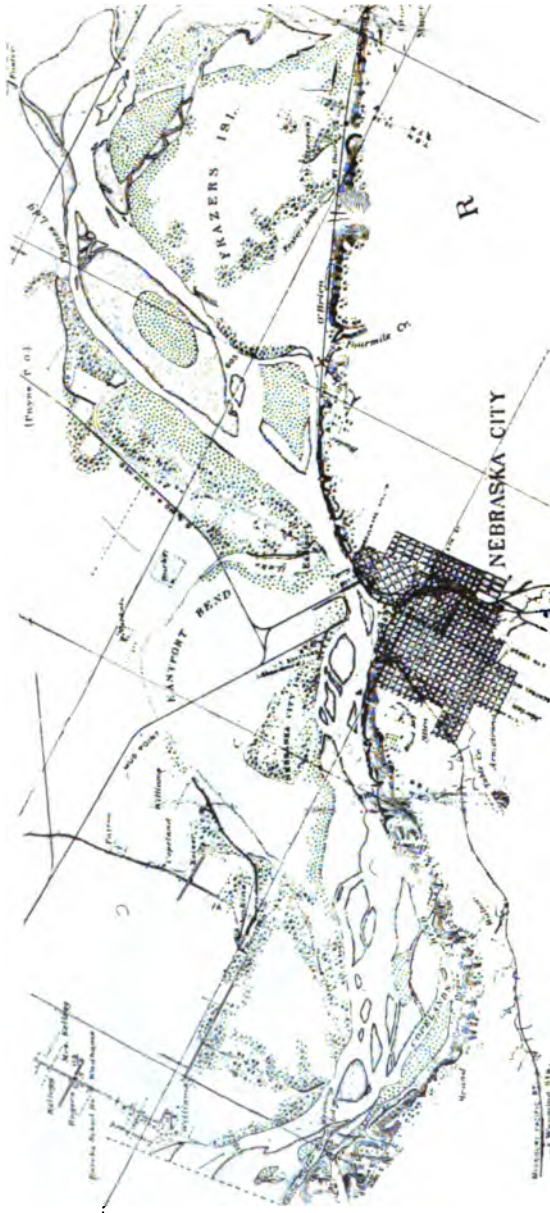

FIG. 6.—The Missouri River opposite Nebraska City, after the ice gorge and high water of 1886–87.

fine the river permanently west of Nebraska City Island; I built a solid embankment, like a levee, completely across the old channel and a dike of brush and stone of the same class as at Blair Crossing, and no water was allowed to go through the old channel of the river. That led to rather an interesting question: What State is that island in? It had been in the State of Nebraska; the river had not washed it away, it had not deserted it; but while the west channel, which was usually the inferior channel, was temporarily larger than the east channel, I put an end to the east channel so that the island was forcibly attached to the State of Iowa, while it was previously a part of the State of Nebraska. Nobody lived on it, but I felt doubt as to what State it belonged to. The bridge was built on the selected location. The river has cut it above the point held by the protection work, but the government has taken the matter in hand, and what was a great sand bar, utterly wild, is now covered with willows and somebody has built a house there and lives in it.

We are coming down the river, and the view* before you exhibits the Rulo Bridge, 50 miles below Nebraska City. This is a place where there was comparatively little difficulty in controlling the river, though a dike was put in as shown. This bridge has three spans of 375 feet each besides the approach spans. The principal feature of the structure arises from the fact that there was no rock found in position, but only clay. The upper clay was very hard; under it was sand or gravel, and then another layer of clay. I went through the upper clay, through the sand and gravel, and put the bridge on the clay below; this was the second bridge on the Missouri River that was founded on clay.

We come now to a point where trouble is brewing to-day and that is at Atchison. You see the river as it was in 1879 (Fig. 7). You will observe the course of the river, cutting here and there and causing a great deal of trouble. Before the Atchison Bridge was built the course of the river was different from that which it now has, and which makes a very bad current through the bridge. This view, Fig. 8, is eleven years later. You will observe that a portion of the river has entirely changed its shape; at that time a lot of revetment work had been done to protect the bridge. In 1891 the river cut right behind the protected bank and caused all

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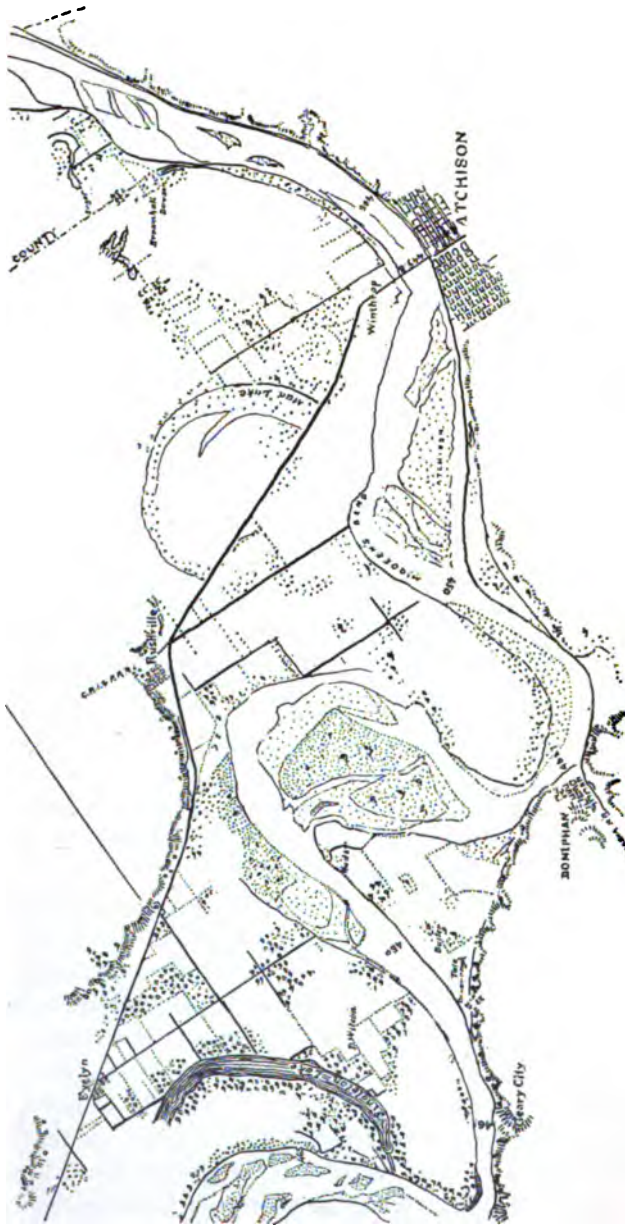

FIG. 7.—The Missouri River opposite Atchison in 1879.

FIG. 8.—The Missouri River opposite Atchison in 1890.

the troubles that have since followed. This map* was taken from the Missouri River Survey of October 30, 1894. The old cut-off and the old channel are shown, as well as the present channel. The result is that the railroads which formerly ran at a safe distance from the river are now all gone except one, which is the only road from the east into Atchison. A town of 1500 people is gone, and they are now making every effort they can to hold the river where it is, and are even cutting a canal to aid that purpose. The river has cut back of the prolongation of the centre line of the bridge. The next three months will determine whether or not the river will go down below without passing through the bridge.

This view† shows Kansas City as it was in 1879. The Kaw River comes as shown. When the State line between Kansas and Missouri was located it was run south from the mouth of the Kaw River, and when the Kansas City Bridge was built, in 1867, the shore was revetted. The revetment has held very well, as rock is not very deep. There was an old channel which formed an island, and a man built a house on it, he lived there, hoping in twenty years, to gain a title to the island; after he had been there nineteen years the river washed the island entirely away; no title was ever taken.

In conclusion, I trust that I have made clear to you the differences between a silt-bearing river and a clear stream; the difficulties presented by the former for the construction and maintainance of bridges, and the methods adopted to obviate them. Each bridge presents its individual problem, but the accumulated experience of previous structures is an invaluable aid in their solution. I thank you for the kind attention that you have given to what I promised at the outset would be an informal talk.

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† Not reproduced.

TEMPERATURE OF GASES FROM LEAD FURNACES.

By MALVERN W. ILES.

In the sheet-iron pipe leading from two blast furnaces smelting silver, lead and gold ores a series of tests to ascertain the temperature of the escaping gases was begun March 8th, 1895, and lasted for twenty-eight days.

The smoke and fume passed from the top of the furnace to the top of a brick dust chamber, through a five-foot pipe. Into the side of this pipe there was tapped an 1¼" hole, through which was inserted a dial pyrometer made by the Standard Thermometer Co. of Peabody, Mass.

This pyrometer registered up to 380° F.—The expansion rod extended into the smoke six inches.

During every three hours, both night and day, a reading was taken from two furnaces, side by side of exactly the same size, the same ore charge, the same blast, and in short all other conditions exactly the same so far as possible. The general average for 28 days of all readings showed a temperature of 214° F.—.

Both of these furnaces were "hanging" alike—that is to say they had practically the same amount of accretions of sulphide of zinc and sulphide of lead upon the side walls.

Just in accordance with the increased amount of wall accretions, did the temperature of the gases increase, and for nine consecutive days there were taken readings every three hours on both shifts, using the Siemen's copper-ball pyrometer as a check against the Standard Pyrometer. The daily averages for these nine days will be given in order to show how accurately these pyrometers check each other; viz:

	SIEMEN'S COPPER-BALL PYROMETER.	STANDARD PYROMETER OF PEABODY, MASS.
1	250	287
2	273	272
3	217	221
4	301	306
5	323	303
6	320	329
7	335	318
8	301	298
9	290	288
	2610	2622
Average	290° F.	291° F.

It will be observed that the average temperature is practically the same, and the writer will state that for quick work and for all practical purposes the Standard pyrometer is much to be preferred, owing to its great simplicity, reliability and durability. The men can take readings at any and all times with as much readiness as the noting of time from a clock. This standard pyrometer will be found remarkably serviceable in a score of places about industrial works, particularly smelters.

It is, however, only fair to say that the Siemen's pyrometer can be used in many places where the Standard pyrometer is not applicable, and that this instrument should be used as a check upon the various kinds of pyrometers found at industrial establishments.

The writer is indebted to Mr. Fred W. Gordon, of the Philadelphia Engineering Works, of Philadelphia, Pa., for the Siemen's pyrometers, especially made at these works for use at the Globe Smelting and Refining Company, at Denver, Col.

Generally speaking it can be safely stated that the temperature of the gases from blast furnaces smelting argentiferous lead ores will be found to range from 200 to 300° F. Of course this temperature is dependent upon many things, such as the size of the furnace, the height of ore column, the amount of blast used, and particularly the presence of many or few wall accretions. Numerous other obvious factors are also influential.

AUGUST 30TH, 1895.

TEMPERATURE OF LEAD SLAGS.

BY MALVERN W. ILES.

IN running blast furnaces for argentiferous lead-smelting, the practical metallurgist is confronted with a large number of difficulties, involving a wide range of knowledge for their ultimate and complete solution. The difficulties present themselves from faulty construction of the furnace, from faulty engines, boilers and blowers unable to produce the proper amount of oxygen at the right time, and from a host of mechanical difficulties, which are not generally found in conducting any other kind of blast furnace. Difficulties also constantly crop up of a chemical nature; and one seeks in vain for help from all the published literature obtainable on lead

metallurgy, and possibly from works on the metallurgy of copper and iron as well.

It will be readily conceded by all, that the proper temperature of the slag is of the utmost moment. Yet how difficult is this to obtain, and how very difficult to maintain.

One may have a line of a dozen furnaces, all built exactly from the same plan—and using the same blast—the same charge to the pound, and having all other conditions the same, so far as possible, and yet, from one furnace the slag will be running hot and perfectly fluid, while from the next it will be cold and viscous, so that no two furnaces behave alike. Whilst we are sure there are good reasons for these apparent anomalies and contradictions, yet the causes are often very obscure.

With the hope of throwing some light upon the temperature of these slags as they flow from the furnace, the writer was induced to make a very extended series of experiments lasting for fifty-seven days, on each of which there were recorded from four to six determinations.

I wish to acknowledge very valuable aid from my assistant, Mr. H. H. Alexander, who carefully conducted most of this work, even in the face of the most confusing and conflicting results.

It gives me great pleasure, also, to acknowledge valuable aid and counsel from Mr. F. W. Gordon, of the Philadelphia Engineering Works. Mr. Gordon furnished us with the formulas, and detailed the method for our experiments, which may be described as follows:

A steel bar weighing from one to two pounds is placed in a hole in the slag runway, or trough of the furnace, so that the full flow of slag passes over it. The slag is then tapped from the furnace, and flowing over the steel, heats it to the temperature of the slag. As soon as the slag ceases to flow, the steel is immediately removed, along with any molten slag which may adhere to it, and both the steel and attached slag are placed quickly in a weighed quantity of water, in which the temperature has been carefully noted. From the resulting temperature is subtracted the original temperature of the water. This difference equals the rise due to slag and steel. This difference, multiplied by the weight of the water, is to be divided by the product of the weight of steel and its specific heat, to which is to be added the weight of slag and its specific heat, while to the quotient is to added the original tempera-

ture of the water. The result equals the temperature of the molten slag.

This can possibly be expressed more clearly by the use of the following equation, viz.:

$$\left(\frac{\text{(Rise in temp. due to steel and slag)} \times \text{Weight of water}}{\text{(Wt. of steel)} \times \text{(Sp. Heat of steel)} + \text{(Wt. of slag)} \times \text{Sp. H. of slag}}\right) + \begin{matrix}\text{original}\\ \text{temp. of}\\ \text{water.}\end{matrix}$$

= Temperature of slag.

In our experiments we used a papier mache bucket, which was first weighed, and then into it was poured ten pounds of water. A piece of round steel, three inches long, was cut from an 1¼ inch bar. This weighed nearly two pounds, and was placed in the hole in the run-way of the furnace, and as soon as the furnace contained slag to run a pot without any blast escaping at the tap-hole, it was tapped.

While the slag was running the temperature of the water was taken.

The furnace was plugged up as soon as the pot was full of slag, and the steel with adhering slag was thrown quickly into the bucket of water. The water was then carefully stirred with a wooden stick and a thermometer placed in the water, and the rise in temperature noted. The water in the bucket was decanted from the slag and steel; the slag was dried and weighed, giving in one example these results:

Weight of steel used, ...	1.875 pounds.
" " slag on steel, ...	0.450 "
" " water in bucket, ...	10.000 "
Temperature of water before experiment, . . .	62° F.
" " " after "	110° F.
Rise in temperature due to slag and steel, . . .	48° F.

Then, according to formula, we have:

$$\frac{10 \times 48}{(1.875 \times .1138) + (.45 \times .2)} + 62° \text{ F.} = \text{Temp. of slag.}$$

Or,

$$\left(\frac{480}{.213375 + .09} + 62\right) - \left(\frac{480}{.303375} + 62\right) = 1582 + 62 = 1644, \text{ or Temp. of slag.}$$

The steel is to be weighed after each experiment. Two pieces of steel were used, one weighing 1.875 pounds, and one piece weighing 1.07 pounds. In nearly every case the smaller weight of steel gave higher results.

Thinking the smaller piece more nearly approached the temperature of the slag, and wishing to see if this were true, the slag was

held in the furnace until two pots had accumulated. The large piece of steel being then placed in the runway the slag was tapped. This, however, gave no higher temperature than the one pot, and still much lower than that indicated by the small piece of steel.

The writer is unprepared to draw any general conclusion from these strange results, which doubtless will be ultimately cleared up.

We give a few temperatures, classified according to date and furnace, and stating the size of steel bar used; the small piece weighed 1.07 pounds and the large piece weighed 1.875 pounds.

Date, 1895.	Time of day.	Furnace A.	Furnace B	
March 22	2 P. M.	1628	1556	Large Piece of Steel
" 22	4 "	1543	1588	" " " "
" 23	2 "	1718	1943	Small " " "
" 23	4 "	2110	2135	" " " "
" 25	2 "	1982	2682	" " " "
" 26	2 "	1606	1903	Large " " "
" 27	2 "	2284	2321	" " " "
" 29	2 "	1644	1698	" " " "
" 29	3 "	2357 (a)	1651 (b)	a—Small (b)—Large

The average of the nine determinations on furnace A was 1878°F., for furnace B it was 1642°F.

Now by collecting all the determinations made with the octagon Canton steel piece weighing 1.07 pounds we find the temperature to be 2170°F., whilst by using the large piece of steel which weighed 1.875 pounds and composed of round Canton steel we find the temperature to be 1641°F., or a difference of 529°F.

We have been unable up to this present time to reconcile this enormous discrepancy, but will say that the heavy piece of steel seemed to give more satisfactory results in every way. It will be noticed that the small piece of steel was octagonal in shape, whilst the large piece was round, and yet this does not seem to account for the variation.

We observed that the amount of slag which is removed by the steel bar effects greatly the results obtained, and it was noticed that the larger the amount of slag thus removed by the steel bar the *lower* the temperature of the slag, and the less slag removed the higher the temperature seemed to be. This discrepancy seems to be due to the figure we have used for the specific heat of the slag; we are inclined to the belief that it is too high.

Mr. George W. Goetz has placed the specific heat at 0.18, whilst Mr. F. W. Gordon has placed it at 0.20.

In this connection it may be interesting to state that Mr. Geo. W. Goetz took to his laboratory a sample of lead-slag from one of the Colorado smelters and determined the specific heat to be 0.18, and the melting point at 2012° F. to 2156° F.

The highest temperature of the slag as it flowed from the furnace, according to several hundred observations was 2334° F., and the lowest determination was 1579° F. The general average of all determinations was 1893° F.

Upon mature consideration, we are led to the belief that many of our early determinations were too low, and that generally speaking the figure 2000° F. is a very close approximation of the true temperature. During the time these observations were made, over 20,000 tons of ore were smelted, and a large variety of ores were treated and the slag had wide ranges in composition. It is with the utmost regret that the writer is forced to state that he has not up to the time of writing this article been able to trace any relation between the temperature of the slag and the:

(*a*)—Bullion produced.
(*b*)—Tons ore smelted.
(*c*)—Tons matte produced.
(*d*)—Assay of the slags in either silver or lead.
(*e*)—Assay of the bullion.
(*f*)—Composition of the matte.
(*g*)—Analysis of the slag.
(*h*)—Composition of the ore.

It is also strange to state that neither were we able to see any relation between the temperatures we obtained, and the percentage of fuel; for example the high percentage of fuel did not always produce the hottest slag. During this run the highest percentage fuel used was 15.4 and the lowest was 13.0. This percentage was based upon the total ore charge, the limestone flux, and the slag used upon the charge.

The full average during these experiments was 13.9 per cent.

In conclusion we will state that whilst we are sure there must necessarily exist some relationship between the temperature of the slag and the substances used in producing the slag, and likewise the products resulting from this smelting operation—but as yet we have been unable to find the key which will unlock this store-

house of knowledge, which is destined to play a very important part in the economic treatment of ores containing gold, silver and lead.

Long familiarity with these slags enables the metallurgist to know instantly whether the slag be sufficiently hot, and likewise positively, which is the hottest slag when several furnaces are running side by side.

It would seem that there should be some more sure, positive and scientific method of ascertaining the temperature of the slag than the dependence upon a practiced eye.

The slag looks very differently on different kinds of days, for example when the sun is shining brightly, and particularly when it is shining upon the flowing slag, the latter looks cold. On dark days it always looks hotter, and at night one can best tell the true temperature with the eye.

Sometimes slags are actually cold for the lack of fuel, and often an excess of fuel will heat up the tops, and the lining of the walls so much that the slag will not obtain a temperature commensurate with the fuel.

Many furnaces produce cold slags from want of oxygen to burn the carbon in the furnace.

Slags containing a large amount of alkaline earths will often look very cold, run thick, curly, and be very brittle, and the furnacemen will say the slag is cold; yet if under these circumstances the temperature be taken one will find invariably that the slag is of a high temperature. Plainly under such circumstances we do not want more fuel, but a change in the charge, lessening the amount of alkaline earths, or, what is practically the same, increasing the amount of silica upon the charge.

In the writer's belief the hotter the slag, the more perfect is the separation of the matte, and consequently the less the losses of lead and silver. It is also believed that careful study along the lines above indicated may lead ultimately to positive results, which we have not yet obtained and which will be of commercial import.

CONTRIBUTIONS FROM THE ANALYTICAL LABORATORIES OF THE SCHOOL OF MINES.

THE ASSAY OF PLATINUM.

By EDMUND H. MILLER.

THE work described in this article was undertaken in the hope of finding a rapid method for the determination of platinum which should be sufficiently accurate for commercial purposes

PART I.

The best known analytical methods are those of Berzelius (*) and of Gibbs (†). They are certainly inadmissible for technical work on acount of the great length of time and labor required. An approximate wet method in use to-day is in brief as follows: Dissolve a large quantity of the ore, say 50 grams, in aqua regia by repeated treatments, dilute filter, add alcohol equal to 60 per cent. of solution, and precipitate the platinum as the double chloride of platinum and ammonium by adding a strong solution of NH_4Cl; filter, wash with diluted alcohol, dry and ignite, and weigh the spongy platinum. This method is not adapted to the assay of low-grade ores, and gives good results only when the operator can judge by experience what percentage of iridium is present from the amount of red color in the precipitate of the double chlorides. It has the objection common to all wet methods—the length of time required for complete solution of the platinum.

METHOD OF DEVILLE AND DEBRAY. (‡)

Take 50 grams of the sample and melt in an ordinary crucible with 75 grams of lead and 50 grams of galena; add 10 to 15 grams of borax and heat to the melting point of silver, stirring from time to time till fusion is complete, than add 50 grams of litharge, or more, until it is in excess, which will be shown by no more SO_2 being evolved. Allow the crucible to cool, break and weigh the button. The theory of the assay is as follows: The platinum mineral containing iron dissolves slowly in the lead; it is attacked by the PbS, which converts the iron to sulphide and gives metallic

* Mitchell's Assaying, pp. 624.

† Crooke's Select Methods, pp. 458 and seq.

‡ Ann. de phys. et de chemie 1859, vol. 56, p. 385-496.

lead, which helps alloy with the platinum; the iron and copper become sulphurized and go into the slag; the iridosmium goes to the bottom of the button. The subsequent addition of litharge is to decompose the PbS and FeS in the slag and render it more fusible. After weighing, the bottom of the button, containing the iridosmium, is sawed off and a weighed portion of the upper part is cupelled for the platinum. The iridosmium in the lead button is usually disregarded, but the platinum in the lower part may be determined as follows: Weigh the lower part and treat with ten times its weight of nitric acid, one to one, to dissolve out the lead; wash by decantation and weigh; dissolve the finely divided platinum in aqua regia, pour off, dry, and weigh the iridosmium; the difference in the weights gives the platinum in the button, which is then added to that of the platinum in the upper part as determined by cupellation. The cupellation may be done alone or by the aid of silver. Cupellation by means of silver: add of pure silver 5 to 6 times the weight of platinum supposed to be present, and cupel at a high temperature. The excess of weight of the button over the silver added gives the weight of platinum. The loss of silver in this cupellation is considered insignificant. The silver may be dissolved in sulphuric acid and the platinum weighed direct. Cupellation alone: a portion of the original lead button is cupelled as usual until it freezes; it is then removed from the furnace and immediately fused by an oxyhydrogen blowpipe until most of the lead has been oxidized; it is then transferred to a cut-lime cupel and the operation continued until all the lead has been removed. After cooling, the button is washed with hydrochloric acid and weighed together with any globules found in the cupel. After determining the amount of platinum as above, Deville and Debray subtract 4% for the associated platinum metals. They state that the most laborious methods do not give much better results. This method though, doubtless fairly accurate, is not a convenient one, as very few assayers have an oxyhydrogen blowpipe at their disposal. The figure 4% would only be applicable to Russian ores.

Perry's Method for Platinum Alloys.*

In platinum alloys, or native platinum, the metals to be determined are base metals, Ag, Au, Pt, and iridosmium. Base metals

*Engineering & Mining Journal, January, 1879.

are removed by cupellation. Silver is dissolved by concentrated sulphuric acid. Platinum, when alloyed with twelve times its weight in silver, is soluble in nitric acid. Gold is soluble in aqua regia, and iridosmium is unaffected. The method is based on the preceding facts, and is conducted as follows:

Weigh out 100 to 200 milligrams of platinum alloy, and add a known weight of silver which shall be sufficient to produce a perfect cupellation; wrap in sheet lead and cupel at a moderate temperature until near the end of the operation, when it must be placed in the hottest part of the furnace to prevent freezing; the button must remain in the muffle until all the lead is gone. The loss in weight of the button is base metal. Flatten the button, anneal, roll out thin, anneal again, and make up into a cornet as in the gold bullion assay; introduce into a flask and part with concentrated sulphuric acid, boiling for several minutes. Wash, anneal and weigh; the loss in weight equals silver added plus silver in alloy. The residue of Pt. Au., and iridosmium is alloyed with twelve times the amount of silver that there is platinum present, rolled into a cornet as before and parted with nitric acid, 1.16 Sp. Gr., and then with nitric acid, 1.26 Sp. Gr., washed thoroughly, annealed and weighed. The loss in weight is platinum. The residue is treated with aqua regia and the gold obtained by difference; the final residue is iridosmium. The characteristic feature of this method is the solution of the silver platinum alloy in nitric acid, and also its weak point, as all the platinum is not dissolved when the ratio of silver to platinum is 12:1. No attempt is made to remove or allow for the associated platinum metals.

Before proceeding to the experimental portion of this article I must give an extract from an article by George Matthey,* which furnished some ideas for my work. "To prepare pure platinum melt with six times its weight of pure lead, granulate, and then treat with nitric acid diluted with eight times its volume of distilled water. This dissolves most of the lead, silver, palladium and some rhodium. Platinum, lead and iridium, etc,, are left. Treat with aqua regia, the solution contains all the platinum, a little rhodium, while the iridium is left. Precipitate the lead by H_2SO_4 avoiding excess, then the platinum as double chloride. Most of the rhodium stays in solution, giving it a pink color; the double chloride precipitate contains traces of rhodium which are removed by fusion with $KHSO_4$."

* Chemical News 39, p. 175.

PART 2.

Work was begun on a high grade Russian ore, which was free from sand and from which the gold and silver had been removed by amalgamation.

Wet Methods: 2.5 grams of the ore were treated three times with aqua regia until all the platinum was dissolved; then diluted with water, filtered and washed; the filtrate was evaporated to dryness and redissolved in HCl and H_2O and refiltered to remove any dust which might have fallen in during the long treatments with aqua regia; the filtrate was made up to 200 c. c. In a portion of 50 c. c. the platinum was determined electrolytically to be 83.11%. In another portion the platinum was precipitated as K_2PtCl_6; in an alcoholic solution this gave Pt 82.54%. The iridosmium was 3.69%.

Perry's Method: .3548 grams of ore were mixed with 40 grams of test lead and scorified at a high temperature; the charge was allowed to cool in the scorifier; the button weighed about 10 grams and was malleable: .3527 grams of silver were added, and the button cupelled at a moderate temperature till near the end, when the heat was raised; the button froze finally and was then removed; it weighed .7848 grams, showing that not enough silver had been added to prevent freezing before all the lead was removed; it requires more than a weight of silver equal to that of the platinum to prevent freezing. The button was recupelled after adding more silver (.9429 grams); it did not freeze, was well formed, and easily detached from the slag. (The total silver added was between four and five times the platinum present.) The button was rolled out and parted with boiling, concentrated sulphuric acid, the residue weighed .3483 grams, to this 4.18 grams pure silver were added and the whole recupelled after wrapping in sheet lead; the button was treated with HNO_3, 1.16 and 1.26, which gave a black solution from which platinum separated on standing; * the residue weighed .0448 grams, which gave 85.81% Pt, 1.26% iridosmium. The iridosmium contained platinum. This method was tried again, using .511 grams of the ore and treating the residue with concentrated nitric acid, 1.42 Sp. Gr., after the 1.26 acid; this gave 76.0% platinum and 5.1% residue, this residue also contained platinum.

* This deposit was found to contain platinum and silver.

Modification of the method of Deville & Debray, and Matthey: .6270 grams of the ore was scorified with 40 grams of test lead in a hot fire, the button weighed about 6 grams and was brittle; it was placed in a beaker and boiled with 1.26 HNO_3 and then treated with 1.42 HNO_3 until no more dissolved, then diluted, filtered and washed, dried, and the paper burned; the residue weiged .6002 grams; this was then treated with aqua regia to dissolve the platinum; loss in weight .5084 grams, 81.08% Pt. This method was repeated twice, using more dilute acid for the solution of the lead, and igniting the residue between the two treatments, as will be explained later.

Results were:

A	Platinum 74.48%.	Iridosmium 4.86%.
B	Platinum 84.72%.	Iridosmium 5.29%.

The only result from this work is to show conclusively the impossibility of using small samples of Russian ore for assay, and emphasizing the necessity of getting an average from the fusion of a large amount, say 50 grams, as recommended by Deville and Debray. Unfortunately I did not have at my command a large amount of this platinum ore, so I could not continue the work on satisfactory amounts, but had to use platinum foil and a platinum alloy.

Platinum Foil (*)

Modified Method: In obtaining the following results the platinum was scorified with 40 grams of test lead, as already described.

No. 1. Weight of platinum 1.0514; weight of button, Pb and Pt, 11 grams; after one treatment with nitric acid, weight Pt 1.1613, showing that all the lead was not removed. After second treatment, weight .9966, which equals 94.80 % platium.

No. 2. Weight of platinum 1.0929; weight of button, Pb and Pt, 11 grams. Treated with diluted and concentrated nitric acid, filtered, and the paper burned; then as lead seemed to be present, shown by a slight yellow tinge of oxide, it was treated again with nitric acid, 1.42, then with dilute and refiltered; weight 1.0600, which equals 96.9 %.

No. 3. .8678 grams of platinum gave .8850 grams residue, or 101.9 %. The acid used was 1.12 Sp. Gr.

No. 4. Weight platinum .3825. Treated with 1.08 HNO_3 gave

*The foil used for this work was specially refined and was the purest obtainable.

104.9 % platinum; after retreating with 1.42 HNO_3 gave 95.2 %.

No. 5. Weight platinum .3303. After treatment with 1.08 HNO_3 gave 106.41 %; after second treatment with 1.42 gave 98 %.

No. 6. Weight platinum .4350. After treatment with 1.08 HNO_3, gave 108.58 %; not retreated.

The slag from the scorifiers was examined, but showed no platinum. It seemed from the above-mentioned and other experiments that a certain nearly constant quantity of lead remained undissolved by nitric acid, 1.08 Sp. Gr., while long boiling with concentrated acid, dissolved some platinum. This difficulty was overcome by igniting the residue after the first treatment, and so oxidizing the lead, thus rendering it soluble in diluted acid.

No. 7. Weight platinum .5900. After treatment with 1.08 HNO_3 .6339 or 107.44 %. It was then ignited and treated with 1.42 HNO_3, weight .5781 or 98 %.

No. 8. Weight platinum .6218. After treatment with 1.08 HNO_3; .6692 or 107.62 %. After igniting and treating with 1.34 HNO_3 98.23 %.

No. 9. .4266 grams of platinum were scorified with 50 grams test lead, the button weighed 15 grams; it was treated with 1.08 HNO_3; then ignited in an open muffle in a porcelain capsule, and retreated with 1.08 HNO_3 for 15 minutes, just below boiling; weight platinum .4200 or 98.45 %.

No. 10. Same as No. 9, gave 97.63 %.

The filtrate from the first treatment with nitric acid was tested with KI after precipitating the lead with sulphuric acid and a trace of platinum found. This was confirmed by evaporating the solution to dryness, dissolving in aqua regia, evaporating again, taking up with water and adding KCl and alcohol, which on standing gave a slight precipitate of K_2 Pt Cl_5.

The filtrate from the second HNO_3 treatment gave no test for platinum, but showed that considerable lead was removed.

The solution of platinum in aqua regia was tested for lead, but none was found. This shows the loss of platinum to be in the first treatment with nitric acid.

No. 11. Weight platinum .5673. Treated button from usual scorification with HNO_3 1.05, then after ignition, with 1.10 HNO_3 just below boiling point for about ten minutes; weight platinum .5656 or 99.70 %.

*No. 12. Weight platinum .528. Treated with 1.08 HNO_3 then ignited in muffle, then treated with 1.16 HNO_3; weight platinum .5265. or 99.72%.

*No. 13. Weight platinum .5245. Treated throughout with 1.08 HNO_3; weight platinum .5230 or 99.71%.

I regard the last data as expressing the limit of accuracy of the method and the result as all that could be desired for practical purposes, provided the method will work as well or nearly as well on impure material as it does on pure platinum.

Platinum Alloy.

Perry's Method:

No. 1. Two portions of half a gram each were cupelled with sheet lead and weighed amounts of silver (.2357 and .2367 grams); after cupellation the buttons were parted with boiling concentrated sulphuric acid, the residues combined, washed, weighed (weight .15142) and alloyed with about thirteen times their weight of silver (2 grams), hammered out and parted; first with 1.16 Sp. Gr. nitric acid; then with 1.26 Sp. Gr. nitric acid, in a porcelain capsule; weight of residue was .05116 grams, which gives platinum 10.026 %. The residue of gold, iridosmium and iridium, contained platinum; it was treated with aqua regia, decanted and washed, the final residue of iridosmium weighed .00234 grams, .234 %. The difference between this weight and that of the previous residue is considered gold by Perry's Method, this gives 4.88 % a result undoubtedly to high. The silver was found to be 32.53 %; the rest of the alloy was lead.

No. 2. 500 milligrams of the alloy were treated as in the previous assay, except that the silver added to the residue before cupellation was 1.4 grams, or about nineteen times the weight of the residue. The weights were as follows: First residue Au, Pt, Ir and IrOs. .07606 grams. Second residue Au, IrOs and Ir .02460 grams. Final residue IrOs .0011 grams. Equivalent to platinum 10.29 %; gold, 4.70 %; iridosmium, .22 %. From the solution obtained by treating the second residue with aqua regia .00366 grams of platinum were recovered, showing that even though the ratio of platinum was 27: 1 all the platinum did not dissolve in nitric acid.

*These figures were obtained by Mr. C. S. Videon.

PROPOSED METHOD:

No. 3. Two portions of the alloy of one gram each were mixed with test lead and scorified at a good heat until they covered over; then poured and buttons hammered to detach slag; the buttons were malleable and weighed about twelve grams each. They were treated with 200 c. c., of nitric acid, 1.08 Sp. Gr., in a large beaker until the action ceased, then filtered and washed with water. The papers containing the residues were burned in a porcelain capsule, and then transferred to the muffle and ignited for ten minutes with the door open, after cooling they were heated to boiling with 1.08 nitric acid for several minutes, washed, ignited and weighed; weights were A .14802, B .15073. They were then warmed with dilute aqua regia (1:3) for a few minutes, which readily dissolves the gold and platinum in the finely divided state in which they are left, diluted, filtered, washed and the residues ignited and weighed. The residues contain both iridium and iridosmium; weights were A .01075, B .01020. These were then treated with strong aqua regia to dissolve the iridium and then reweighed. Weights were A .00550, B .00550.

The marked difference between these residues and those obtained by Perry's Method shows that iridium is probably dissolved with the gold, and also that some decomposition of the iridosmium is affected by the fusion with a large amount of silver. The iridium dissolved by the strong aqua regia was identified by the brick red precipitate it gave with ammonium chloride. The gold was precipitated by zinc after an incomplete precipitation of the platinum by ammonium chloride, then cupelled with silver to remove small quantities of platinum and parted with nitric acid, 1.16 and 1.26 Sp. Gr. The gold weighed A .03508, B .03384.

Results are:

	PLATINUM.	GOLD.	IRIDIUM	IRIDOSMIUM.
A	10.34	3.384	.525	.55
B	10.54	3.508	.47	.55

No. 4. The method of precipitating the gold in the preceding assays was not satisfactory on account of the length of time necessary. In the next assays the gold was precipitated by oxalic acid in the presence of the platinum, thus shortening and simplifying the method.

Two portions of one gram each of the alloy were run as in No. 3. The first residues, gold, platinum, iridium, and iridosmium,

weighed: A .14445 (this result is low, as some adhered to the capsule and could not be weighed), B .14885. Second residues, iridium, and iridosmium. A .0100, B .0100.

The solution of platinum and gold was evaporated just to dryness to remove all nitric acid, then dissolved in water and a few drops of hydrochloric acid, and the gold precipitated by warming with oxalic acid and allowing to stand over night; this was afterwards found to be unnecessary as the gold can be precipitated in half an hour. Care must be taken not to carry the evaporation too far, as the chloride of gold will then be reduced. The gold was cupelled with silver to remove filter ash and any traces of platinum, parted and weighed; weights were, A .03416, B .03450. The gold turned bright yellow on annealing and was satisfactory in all respects.

Results are:

	PLATINUM.	GOLD.	IRIDIUM AND IRIDOSMIUM.
A	10.02	3.42	1.00
B	10.42	3.45	1.00

Extra determinations of gold were made as follows:

No. 5. One gram of the alloy was cupelled with 500 milligrams of silver, then rolled out and parted with concentrated sulphuric acid; the residue was treated with strong aqua regia; the iridosmium remaining weighed .00530. The platinum in the chloride solution was incompletely precipitated by ammonium chloride after evaporation, and the gold and remainder of the platinum in the filtrate were precipitated by zinc and sulphuric acid; the gold was then cupelled with silver and parted as usual. Gold weighed .03434, and was pure.

No. 6. Same as No. 5, except that platinum was precipitated by potassium chloride and the gold by oxalic acid and allowed to stand. Iridosium, .0544; gold, .03420.

No. 7. Same as Nos. 5 and 6, except that gold was precipitated by oxalic acid and in the presence of all the platinum. The details of the precipitation of the gold are as follows: The chloride solution was evaporated just to dryness, but not baked, to remove nitric acid, redissolved in water, and a drop or two of hydrochloric acid added, then diluted to 50 c. c. and heated for half an hour with a gram of oxalic acid. The heating should be continued until the solution clears.

Gold before cupellation, .03501; after cupellation with silver and parting, .03424.

Results are:

No. 5.	Gold by zinc, 3.434%.	Iridosmium, .53%.
No. 6.	Gold by $H_2C_2O_4$ and time, 3.42%.	" .54%.
No. 7.	Gold by $H_2C_2O_4$ in half hour, 3.424%.	" not weighed.

WET METHODS: Precipitation of platinum by ammonium chloride.

No. 8. One gram of the alloy was scorified with test lead, treated with 1.08 Sp. Gr., nitric acid, etc., as described under "Proposed Method." The solution of the gold and platinum in the aqua regia was evaporated, taken up with water and a few drops of hydrochloric acid, and the platinum precipitated as $(NH_4)_2PtCl_6$ by NH_4Cl, after the addition of alcohol and weighed as metallic platinum; weight equals .0995. The filtrate was treated with zinc and sulphuric acid to precipitate the gold which was found to contain platinum. This was retreated as before and .00352 grams recovered, giving in all .10302 grams or 10.30 % platinum.

No. 9. One gram of the alloy was treated by wet methods throughout, the platinum precipitated as $(NH_4)_2PtCl_6$, in strong alcoholic solution containing ether, ignited in covered platinum crucible; the first precipitate gave .0960 grams; the filtrate containing gold was retreated and .0093 grams recovered; the filtrate from this treatment showed no more precipitate on standing. Result is 10.53 % platinum.

No. 10. In the last method the lead was found to give considerable trouble, so to check the last gravimetric result, another portion of the alloy was cupelled with silver, rolled out and parted with concentrated sulphuric acid, and the residue of iridosmium, iridium, gold and platinum, treated with dilute aqua regia, thus giving a solution of gold and platinum only. The gold was then precipitated by oxalic acid as usual, and the platinum by NH_4Cl, after destroying the oxalic acid. The result by this method is 9.99 % platinum.*

COMPARISON OF RESULTS ON PLATINUM ALLOY.

No. 1.	Perry's Method. Ratio of Ag to residue 13:01,	10.02	4.88
No. 2.	" " " " " " 19:01,	10.29	4.70
No. 3.	(A) Prop. Method. Au by Zinc, ...	10.34	3.384
	(B) " " " " " . . .	10.54	3.508
No. 4.	(A) " " Au by Oxalic Acid, . .	10.02	3.42
	(B) " " " " " " . .	10.43	3.45

*This result is undoubtedly low, but is the best obtained by the method described.

Nos. 10 & 5.	Wet Method for Pt.	Au by Zinc, . .	9.99	3.434
Nos. 9 & 6.	" "	" Au by Oxalic Acid (24 hours)	10.53	3.42
Nos. 8 & 7.	" "	" Oxalic Acid (30 minutes)	10.30	3.424

Perry's method is quite accurate for the platinum, owing to the fact that the trace of lead left after compellation compensates for the platinum left after treating with nitric acid the alloy of platinum and silver. The gold is too high, as in obtaining this by difference, the traces of platinum and iridium count as gold. The iridosmium is low.

In the proposed method a separation of iridium from both platinum and iridosmium is effected, the gold is as accurate as by the wet method, while the platinum is nearly the same. The discrepencies between duplicates are caused by the fact that on igniting in the muffle the platinum gold residue containing lead, the oxide of lead formed causes the residue to adhere to the porcelain capsule, so that it cannot be detached and weighed. I have tried the substitution of unglased annealing cups, but have not overcome this difficulty. The wet method requires very careful manipulation and regulation of the conditions for precipitating the double chlorides, especially in the presence of gold; it also takes five to six times as long as the proposed method. I have found it necessary to ignite the precipitate of double chlorides in a covered crucible very carefully, as the mechanical loss of platinum is much greater than would be supposed and also to examine the filtrate for platinum.

Low Grade Ores.

No. 1. Platiniferous sand. Charge. Ore two assay tons. Litharge 2 A. T. Soda 2 A. T. Borax glass 20 grams. Argol 4 grams. These were mixed and placed in a No. 6 Hessian Crucible, covered with a layer of salt half an inch thick and fused in a coke fire like a gold assay, the resulting buttons were hammered and scorified, then treated with nitric acid as usual.

Results were as follows:

	PLATINUM.	IRIDOSMIUM.
A	6.75 oz. per ton.	3.02 oz. per ton.
B	5.64 " " "	1.80 " " "
C	6.075 " " "	1.31 " " "
D	5.26 " " "	2.71 " " "

C and D were obtained from four assay ton lots.

This sand containing heavy metalic particles was very difficult to sample.

No. 2. Vermilion Earth, Sudbury, Canada.

Charge: Ore 2 A. T. Litharge 2 A. T. Soda 2 A. T. Borax glass 10 grams. Argol 4 grams. Salt Cover. The crucible assay gave good malleable buttons of about 30 grams each; they were scorified with 20 grams of test lead to remove copper. The lead buttons were treated with 1.05 HNO_3 in A and B, in C and D with 1.05 and 1.08 HNO_3.

A	Platinum	4.53 oz. per ton.	
B	"	4.46 " " "	
C	"	4.375 " " "	
D	"	4.385 " " "	

The filtrate containing lead, etc., was treated with an excess of sulphuric acid and the filtrate was found to contain considerable quantities of copper and palladium. No palladium was found with the platinum.

Conclusion. The method described is equally well adapted to the determination of platinum in any material, from a low-grade ore to platinum foil, as the first treatment in the case of a low grade ore collects the platinum from four or even six assay tons in a lead button of about twenty grams, which after scorification yields a button of a size easily dissolved by nitric acid.

In treating a Russian ore at least thirty grams should be melted with lead and the resulting button broken up and sampled for assay. If the ratio of lead to platinum is about 6:1 the button will be brittle and easily broken up for sampling. In scorifying this sample for assay the ratio of lead to platinum should not be less than 30:1, in order to obtain a malleable button from which the slag can easily be detached by hammering.

Suppose an ore to contain Pt, iridosmium, Os, Ir, Pd, Ru, Rh, Ag, Au, Cu, Fe, SiO_2, the scorification removes iron and silica as well as most of the copper and volatilizes some osmium, giving an alloy of Pb, Pt, Ir, Pd, Ru, Rh, Ag, Au, and Cu (?), Os (?), which contains iridosmium. The first treatment with 1.08 nitric acid dissolves most of the lead, all the silver, copper if present, palladium and some rhodium, leaving Pb, Pt, Ir, (Ru, Rh, Os)? Au and iridosmium. The second treatment with nitric acid after ignition takes out the rest of the lead. The residue should be treated with dilute warm aqua regia, 1:5, which will dissolve the finely divided gold and platinum, and leave the iridium, iridosmium, and probably some of the trifling amounts of Ru, Rh, and Os present. The resi-

due after weighing is to be treated with concentrated aqua regia if a separation of iridium from iridosmium is desired. The gold is precipitated from the chloride solution by oxalic acid after evaporating to remove nitric acid and cupelled.

In regard to the behavior of some of the rare platinum metals I cannot speak from experience, but refer to the articles already cited by Deville & Debray, and George Matthey.

I think this method will give results in percentage of commercial platinum, which always contains traces of associated metals, very close to the truth, and hope that it will prove of practical use.

In conclusion I must express my thanks to Mr. C. S. Videon for coöperation in part of the work described.

LECTURE-NOTES ON ROCKS.*

For Use without the Microscope.

By J. F. KEMP.

Chapter I. Introduction. Rock-forming Minerals. Principles of Classification.

A rock may be best defined as any mineral or aggregate of minerals that forms an essential part of the earth. The word mineral is used because this is our most general term for all inanimate nature, and while the lifeless remains of organisms often contribute in no small degree to rocks, no rock is made up of those which are still alive. In instances a single mineral forms a rock, but among minerals this is the exception. By far the greater number are in such small amount that they cannot properly be considered rocks. Rock-salt, ice, calcite, serpentine, cemented fragments of quartz, kaolin and a few others are in sufficient quantity, but the vast majority of rocks consist of two or more. The condition that a rock should form an essential part of the earth is introduced to bar out those minerals or aggregates which, though important in themselves, are none the less insignificant as entering into the mass of

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the globe. Thus the sulphide ores, while locally often in considerable quantity, when broadly viewed are practically neglectable. Yet this is somewhat arbitrary and there are single minerals and aggregates that may properly give rise to differences of opinion. The following pages err, if at all, on the side of demanding that the amount should be large. A rock must also have an individual character, sufficient to establish its identity with satisfactory sharpness. The species cannot be marked off with the same definition as in plants, animals or minerals, and there is here again reasonable opportunity for differences of opinion as to the limits which should be set, some admitting of finer distinctions and greater multiplicity of species than others; but after all has been said, there should be a well marked individuality to each rock species such that any careful and qualified observer may readily see. Too great refinements and too minute subdivisions ought to be avoided. The determining conditions of species will be taken up at greater length when the preliminaries of classification have been set forth, but it must be appreciated that the point of view is also a most important factor. Thus if one is studying the geology of a district with close accuracy, and is tracing out the history and development of its rocks with microscopic determinations and descriptions of minerals and structures which may be minute, finer distinctions will naturally be drawn than those that suggest themselves to one who is engaged in ordinary field work or in mining or engineering enterprises. It is for tne latter class that these pages are prepared and throughout the descriptions and classification here given, the necessary limitations and the practical needs of such observers are always kept in mind. Textural and mineralogical distinctions are alone emphasized where easily visible on a specimen, although never made contradictory of principles of origin and classification that could be carried to greater length and subdivision.

Rocks embrace matter in a great variety of structures and conditions. While in general we picture them to ourselves as solid, yet under the terms of our definition, we have no logical right to bar out liquids or even gases. The physical condition may vary with ordinary temperatures. Thus we cannot reject ice as an extremely abundant and important rock, and yet its solid condition results from water with a moderate loss of heat, and at ordinary temperatures the same molecules may be in a liquid or gaseous state. All that we know of volcanoes indicates that liquid, molten

magmas exist for long periods deep in the earth, yet they are none the less rocks because of their liquidity. In general, however, rocks are solid, and gases or liquids (except water) deserve no further attention. In texture rocks may be loose and incoherent as in sand, gravel, volcanic dust and the like, or they may be extremely dense, hard and solid, as in countless familiar examples. This solidity or massiveness has its limitations, for all observation and experience show that what are apparently solid masses are really broken up by multitudes of cracks into pieces of varying size. All quarries and mines have these, and they may aid or annoy the operators according to the purposes of excavation. They will again be referred to at length. Rocks are also in all cases permeated with minute pores and spaces that admit of the penetration of water and other liquids, especially if under pressure. These are important factors in terrestrial circulations.

The Chemical Elements Important in Rocks.

The chemical elements really important in rocks are comparatively few, and are those which are most widespread in nature. The best estimate that has been made is that of F. W. Clarke, in Bulletin 78, of the U. S. Geological Survey, pp. 34–43. The crust to ten miles below sea level and the air and the ocean are embraced. The composition of the solid crust is reached by averaging up analyses of igneous and crystalline rocks, 880 in all; 321 from the United States, 75 from Europe, 486 from all quarters. Igneous rocks being the source of all the others, furnish the best data for the general chemistry of the globe. The composition of the ocean is then averaged in with that of the rocks on the basis of 7% for the former and 93% for the latter, with a further addition of 0.02% for the nitrogen of the atmosphere. Other ingredients, as the oxygen of the air are less than 0.01% and are neglected.

O	49.98	Na	2.28	P	0.09
Si	25.30	K	2.23	Mn	0.07
Al	7.26	H	0.94	S	0.04
Fe	5.08	Ti	0.30	Ba	0.03
Ca	3.51	C	0.21	N	0.02
Mg	2.50	Cl, Br	0.15	Cr	0.01

The remaining elements may be omitted in this connection, although, as a moment's reflection will show, they include all the common metals except iron and manganese.

There is good ground for believing that toward the centre of the earth the metallic elements become much more abundant, and that near the centre some of the heaviest known are in excess, but these inferences, however well-based, concern materials far beyond actual experience, and of no great moment in this connection. As regards rocks we have to deal with the outer portions of the globe, to which we are accustomed to refer as the crust. This term is not meant to indicate anything as to the condition of the interior, but merely its exterior as contrasted with the inner parts.

The chemical elements above cited are combined, except perhaps in volcanic glasses, in the definite compounds that form mineral species. These compounds change, more or less, in the course of time, under the action of various natural agents, chief of which are water, carbonic acid and oxygen, but at any particular stage, however complex the rock may be, it is made up of definite chemical compounds, though we may not be able to recognize them all. The most important compounds are not numerous and are practically limited to the following: silicates, oxides, carbonates, sulphates, chlorides, and of far inferior moment phosphates, sulphides, and one native element graphite.

As a broad conception in speaking of these compounds it is in many respects advantageous to have the igneous rocks primarily before our minds, because as stated above they are the sources of the others. In taking up the minerals the purpose here is to emphasize their chemical composition and relative importance, not to describe them as would be done in a text-book on mineralogy so as to enable a student to recognize them, for such preliminary knowledge is here assumed. Our purpose is to make prominent the chief chemical compounds entering into the earth, and to prepare the way for a true conception of the range and relations of its constituent rocks.

The Silicates.

The silicates are grouped as follows: the feldspars and feldspathoids; the pyroxenes; the amphiboles; the micas; olivine. The last four groups are often collectively called the ferro-magnesian silicates. Zircon and titanite conclude the list of those important in igneous rocks. In addition there are a number of others that are specially characteristic of altered or metamorphosed rocks, viz: epidote, scapolite, garnet, tourmaline, topaz, andalusite, cyanite,

fibrolite or sillimanite, and staurolite. Finally a few hydrated silicates complete the list.

THE FELDSPARS and their related minerals are all double silicates of alumina and an alkali or an alkaline earth or both. We speak of them as alkali-feldspar, potash-feldspar, soda-feldspar, lime-soda feldspar, etc, based on this fact. They are generally grouped as orthoclase, representing monoclinic feldspar with its two cleavages at right angles (hence the name), and as plagioclase or triclinic feldspar, with oblique cleavages, and one striated cleavage plane. Orthoclase is chiefly $KAlSi_3O_8$, but Na replaces more or less of the K, without affecting the crystal system. Sufficient amounts of soda are however capable of changing the system to triclinic and the feldspar is called anorthoclase. Microcline is also a triclinic variety of potash feldspar, with a cleavage angle slightly less than a right angle, but with peculiar and characteristic optical properties, which are chiefly of moment in microscopic work. The clear, unclouded orthoclase of the later volcanic rocks is often called sanidine. It does not differ essentially from the orthoclase of the older rocks, and the distinction based on geological age is obsolete, but as the terms are still used in the literature of the subject it is well to understand them.

The plagioclase feldspars embrace a practically unbroken series from pure soda-alumina silicate in albite, $NaAlSi_3O_8$, to pure lime-alumina silicate, anorthite, $CaAl_2Si_2O_8$. Various mixtures of these two molecules give the intermediate species, but the two on which special stress is ordinarily placed are oligoclase, with soda in excess and hence called soda-lime feldspar, and labradorite with lime in excess and hence called lime-soda feldspar. If we represent the orthoclase molecule, $KAlSi_3O_8$ by Or; the albite molecule, $NaAlSi_3O_8$ by Ab, and the anorthite, $CaAl_2Si_2O_8$ by An, all the intermediate feldspars can be algebraically expressed. Thus anorthoclase lies between Ab_2Or_1, and $Ab_{4.5}Or_1$, Albite embraces those from Ab through Ab_8An_1; oligoclase, Ab_6An_1, through Ab_2An_1; (the intermediate mixtures Ab_3An_2 through Ab_4An_3 are called andesine); labradorite includes Ab_1An_1 through Ab_1An_2; bytownite Ab_1An_3—Ab_1An_6; anorthite Ab_1An_8 to An. This conception of feldspars as isomorphous mixtures of molecules is a very valuable one and by determining specific gravity, optical properties and chemical composition, one or all, the different members can be identified. Practically, however, in the ordinary

determination of rocks, aside from microscopic work we are forced by the difficulty of distinguishing the intermediate varieties, into the general use of orthoclase and plagioclase, and we rely on the presence or absence of the striations peculiar to the basal cleavage of the latter in distinguishing between the two, but of course experience and familiarity with the general characters and associations of minerals in rocks often enables one to determine very closely the minor varieties. We would naturally look for orthoclase, albite and oligoclase in acidic rocks or those high in silica, while in basic rocks we would expect those near the anorthite end.

All the feldspars have very similar crystal forms when these are developed, as they occasionally are in rocks. When they are small and irregularly bounded, cleavage faces should be sought out and examined with a pocket lense. It is interesting to note that only in igneous rocks do we obtain crystals uniformly developed on all sides, for only in a fused magma do they swim and grow without a fixed support.

The word feldspar is spelled by English writers "felspar," but among Americans the more correct form, based on the etymology, is employed, following the German original "Feldspath."

FELDSPATHOIDS. With the feldspars are placed two other important and closely related minerals, nepheline and leucite, to which may also be added one that is quite rare, melilite. *Nepheline* is an hexagonal soda-alumina silicate $4Na_2O,4Al_2O_3,9SiO_2$, in which some of the Na_2O is replaced by K_2O and CaO. It appears in a subordinate series of igneous rocks that are rich in soda. *Leucite* is an isometric potash silicate, $K_2O,Al_2O_3,4SiO_2$, with a little Na_2O replacing part of the K_2O. It appears as an important rock-making mineral in the igneous rocks of ten or fifteen localities the world over, and is therefore of very limited distribution. *Melilite* is an extremely basic lime-alumina silicate, $12CaO,2Al_2O_3,9SiO_2$, and appears in a few rare basalts.

Reference may also be made to sodalite, nosean and haüyne which are occasionally met, but which are chiefly of microscopic interest.

The feldspars, together with the feldspathoids nepheline and leucite, are the most important of the rock-making minerals in their relations to the classification of rocks.

In order to have a standard series of analyses with which to

compare those of rocks later given, the following table is inserted of theoretical feldspars and feldspathoids. The relative amounts of the several oxides will suggest the extent to which the molecules are present in any rock whose analysis is known:

	OR ORTHOCLASE $KAlSi_3O_8$	AB ALBITE $NaAlSi_3O_8$	AN ANORTHITE $CaAl_2Si_2O_8$	NEPHELINE $Na_8Al_8Si_9O_{34}$	LEUCITE $KAlSi_2O_6$	MELILITE $Ca_{12}Al_4Si_9O_{28}$
SiO_2	64.7	68.6	43.1	45.0	55.0	38.1
Al_2O_3	18.4	19.6	36.8	34.3	23.5	14.5
K_2O	16.9	. . . . .	. . .	. . .	21.5	
Na_2O	. .	11.8 .	. . .	20.7		
CaO	. . . . .	.	20.1 .	. . . . .	. .	47.4

Recalling what has been said about the replacement of the alkalies by one another, and that we never meet any of these minerals chemically pure, according to the formulas above given, and making suitable allowance for this replacement, we may still appreciate that orthoclase and albite, being high in silica, favor acidic rocks, and the others being low in silica, basic ones; that nepheline implies a magma rich in alumina and soda, leucite one rich in potash, and melilite one low in silica and alumina, but high in lime.

THE PYROXENES and the AMPHIBOLES are best described together. Each embraces a series of compounds of the same chemical composition, differing only in physical and optical properties. As the table shows they vary from magnesia silicate through a series of lime and lime-alumina silicates, with an iron silicate generally present. All the pyroxenes have a prismatic cleavage of nearly 90° (87°10′ or thereabouts), while the amphiboles cleave along a prism of nearly 120° (124°11′).

COMPOSITION.	PYROXENE.	AMPHIBOLE.	SYSTEM.
$MgOSiO_2$, $FeOSiO_2$	Enstatite, Bronzite, Hypersthene	Anthophyllite	Orthorhombic
$CaMgSi_2O_6$	Diopside	Tremolite	Monoclinic
$CaFeSi_2O_6$	Malacolite	Actinolite	
$MgAl_2SiO_6$	(Diallage)		
$MgFe_2SiO_6$	Augite	Hornblende	
$FeAl_2SiO_6$			
$NaFeSi_2O_6$	Acmite, Aegirine	Arfvedsonite	

Under the orthorhombic pyroxenes enstatite has least of the molecule $FeOSiO_2$, *i. e.* FeO less than 5%, bronzite has FeO less than 14% and hypersthene the higher values. The increase

brings about a darker color and changed optical properties. The orthorhombic pyroxenes are much less frequent than the monoclinic, but are of wide distribution, especially hypersthene. The orthorhombic amphiboles are of minor importance and are but seldom met.

The light-colored monoclinic pyroxenes are almost pure lime magnesia silicates, and are called diopside. They are chiefly found in crystalline limestones. As iron increases, they pass into malacolite, which may also contain small amounts of the aluminous molecules. Neither of these pyroxenes is of special abundance as a rock maker. When pinacoidal cleavages around the vertical axis appear in addition to the prismatic ones in pyroxenes of the general composition of malacolite they are called diallage and are important in some igneous rocks. But the chief rock-making pyroxenes are the dark aluminous, ferruginous ones, which are called augite, and these are among the most important of all minerals in this connection. The igneous rocks rich in soda, in which nepheline is common, are the ones that contain acmite and ægirine, the soda-pyroxenes.

The monoclinic amphiboles are closely parallel in their occurence and relations to the pyroxenes. Tremolite is met in crystalline limestones. Actinolite may form schistose rocks by itself, but much the most important variety is hornblende, the aluminous variety corresponding to augite. The soda amphibole arfvedsonite is rare.

The pyroxenes and amphiboles are often collectively referred to as the bisilicates, the oxygen of the base being to the oxygen of the silicon, as shown in the first two formulas, in the ratio of 1 : 2. It is also interesting to note that many blast furnace slags are calculated on the basis of the formulas for pyroxene.

THE MICAS. The commonest of these is biotite and its distribution is very wide. It is a complex silicate involving magnesia in large amounts and is often called magnesia mica for this reason. The other bases are hydrogen, potassium, iron and aluminum, and the general formula is $(H, K)_2 (Mg, Fe)_2 Al_2Si_3O_{12}$. It is important in its bearings on the classification of rocks. Phlogopite is of related composition but is almost entirely limited to crystalline limestones. Muscovite, from its richness in potash, is often called potash mica. It is widespread in granites and schists and as an alteration product. Its general formula is $(H, K)\ Al\ SiO_4$.

OLIVINE, the unisilicate of magnesium and iron, $2(Mg,Fe)O$,

SiO_2, completes the list of silicates which are of the first order of importance in igneous rocks. The above name is usually employed in preference to chrysolite. Olivine is practically limited to basic igneous rocks.

Zircon and titanite are interesting microscopic accessories, but as rock-making minerals they are seldom visible to the naked eye.

Along the contacts of intrusions of heated igneous rocks, and in regions where the original sediments have undergone strong dynamic disturbances, with oftentimes attendant circulations of waters more or less heated, a series of characteristic silicates is in each case developed. Garnet, tourmaline, topaz, andalusite, scapolite and biotite are especially characteristic of the former; garnet, cyanite, sillimanite, staurolite, biotite, and muscovite of the latter. Epidote results when feldspars and the ferro-magnesian silicates undergo decay and alteration in proximity, so that the solutions afforded may react on one another.

The hydrated silicates of chief importance include a magnesian series, embracing talc and serpentine, which result from the ferro-magnesian minerals; a ferruginous aluminous series, with much iron oxide, usually collectively called "chlorite," and derived from the iron-alumina silicates; and finally kaolin, the hydrated silicate of alumina that is chiefly yielded by feldspar. Zeolitic minerals are also often met, but rather as vein fillings and in amygdaloidal cavities than as important rock makers.

The oxides include quartz and its related minerals chalcedony and opal, and the oxides of iron—magnetite and hematite and the hydrated oxide, limonite. With these should be mentioned chromite and ilmenite (menaccanite), which are of minor importance. Quartz is found in all rocks high in silica. Magnetite and hematite are at times almost abundant enough to constitute rocks themselves. They favor igneous and metamorphic varieties when present in a subordinate capacity. Magnetite is the most widespread of all the rock-making minerals. Limonite is an alteration product. Chromite is practically limited to the basic igneous rocks and their serpentinous derivatives. Ilmenite is a common accessory in many igneous rocks.

The carbonates are calcite, dolomite and siderite, all three being really members of an unbroken series from pure carbonate of calcium, through admixtures of magnesium carbonate to pure magnesite on the one hand, or with increasing carbonate of iron to pure

siderite on the other. The sulphates of moment are anhydrite and gypsum, the latter the hydrous, the former the anhydrous salt of lime. The one chloride is the sodium chloride, rock salt or halite, and the one phosphate is apatite, the phosphate and chloride of lime. The two sulphides of iron, pyrite and pyrrhotite are the only ones sufficiently widespread to deserve mention, and graphite is the chief representative of the elementary substances, although native sulphur might perhaps with propriety be also mentioned.

We speak of minerals as essential and accessory, meaning by the former term those that constitute a large part of the rock, and that must be mentioned in the definition; by the latter those that are present in small amounts or that are more or less fortuitous. Primary minerals are those that date back to the origin of the rock, as for instance the ones that crystallize out from a molten magma as it solidifies; secondary minerals are formed by the alteration of the primary. Feldspars, pyroxene and hornblende are good illustrations of the former; hydrated silicates of the latter.

The Principles Underlying the Classification of Rocks.

Rocks must of necessity be classified in order to place them in their natural relations so far as possible and to allow of their systematic study. At the same time they are so diverse in their nature and origin that the subject is not an easy one. They must however be grouped on the basis of their structures and textures; or of their mineralogical composition; or of their chemical composition; or of their geological age; or of their method of genesis. One or several of these principles enter into all schemes. On the basis of the first, rocks have been classified as massive and stratified; as crystalline and fragmental or clastic, each with subdivisions on one or more of the other principles. On the basis of the second we have had those with only one mineral (simple rocks) and those with several (complex rocks). The chemical composition as shown by a total analysis (bausch-analysis) without regard to special mineral components is of almost universal application in a subordinate capacity. It must be regarded in the group of igneous rocks and in those that are deposited from solution, chiefly highly calcareous or highly siliceous rocks. The principle of geological age was formerly much valued in connection with igneous rocks, but it is a thoroughly exploded one. The principle of origin or genesis is the most philosophical of all as a fundamental basis, but while in

the greater number of cases it may be readily applied there are some puzzling members whose entire geological history is not well understood. Very early in the development of the subject it was appreciated that there were two great, sharply contrasted groups, according as they had consolidated and crystallized from a molten condition or had been deposited in water either as mechanical fragments or as chemical precipitates. Two divisions have therefore been established, the igneous and the aqueous.

Even a limited field experience soon convinces the observer that many rocks are encountered which cannot be readily placed with either of the two great classes whose origin is comparatively simple. Rocks for instance are met having the minerals common to the igneous, but with structures that resemble those of sediments in water.

Great geological disturbances, especially if of the nature of a shearing stress, may so crush the minerals of any igneous rock and stretch them out in bands and layers as to closely imitate a recrystallized sediment. The baking action of igneous intrusions on fine sediments, such as clays and muds, makes it difficult for an observer, without the aid of thin sections and a microscope to say where the former sediment ends and the chilled magma begins. Sediments buried at great depths and subjected to heat and hot water become recrystallized with their chemical elements in new combinations. These excessively altered rocks have been often grouped into a separate, so-called "metamorphic" division, which was a sort of "omnibus" of unsolved geological problems. This metamorphic group is useful, and the term is a common one in the science, but wherever possible it is well to appreciate the true affinities of its members which though altered are still referable to their originals.

In the following pages these three divisions will be adopted, but the metamorphic group will be reduced to a minimum by remarking, in connection with descriptions of the unaltered, changes that igneous and aqueous undergo.

We take up, therefore, in this order:

A. The Igneous Rocks.
B. The Aqueous Rocks.
C. The Metamorphic Rocks.

CHAPTER II. GENERAL INTRODUCTION TO THE IGNEOUS ROCKS. CLASSIFICATION.

The Igneous rocks are first treated because they have been the originals, according to our best light, from which all the others have been directly or indirectly derived, for either from the fragments, as afforded by their decay, or from the mineral solutions, yielded by their alteration, possibly in the primitive history of the globe, all the others have been produced.

The igneous rocks occur in dikes, sheets, laccolites, bosses and vast irregular bodies, for which we have no single term. Dikes (spelled also dykes) have penetrated fissures in other rocks, and have solidified in them. They therefore constitute elongated and relatively narrow bodies, of all sizes, from a fraction of an inch in thickness and a few feet in length, to others a thousand or more feet across and miles in length. Sheets are bodies of relatively great lateral or horizontal extent, compared with their thickness. They are either surface flows, which may be afterwards buried or else are intruded between other strata. In the last case they are often called laccolites, especially if lenticular in shape. Roughly tubular masses, such as might chill in the conduit of a volcano are called necks. Irregular, projecting, rounded bodies are called bosses. The enormous masses of crystalline rocks like granite that often cover hundreds of square miles, and that frequently appear to have fused their way upward by melting into their substance, overlying rocks, are called bathylites. They have in most, if not all instances, only been uncovered by erosion, for the name means a rock belonging to the depths of the earth. It will be later brought out that the character of the occurrence, whether as dike, surface flow, intruded sheet, or bathylite, has an important influence on the texture.

Igneous rocks are characteristically massive, as contrasted with the stratified structure of the sedimentary, and the term massive is sometimes employed as a synonym of igneous. Other synonymous terms are eruptive and anogene, both meaning that the rocks have come up from below. Many years ago the distinction was made between those that have crystallized deep within the earth, the plutonic and those that have been poured out on the surface, the volcanic. The words intrusive and effusive or extrusive have been employed in much the same way. Between surface flows

and deep-seated masses (bathylites) and their characteristic textures, every gradation is to be expected and is met, and an intermediate group has even been established by some writers for rocks that have cooled as intruded sheets and dikes. This three-fold distinction is not carried out here, the two extremes being believed to illustrate the varieties satisfactorily when accompanied by auxiliary remarks on the intermediate types.

We are tending more and more to employ the word structure to describe the larger features of a rock, as for instance a massive structure as against a stratified, while the smaller features are described as textures, as for instance a glassy texture, a porphyritic or a granitoid, terms that refer to characters which may be seen even on a small fragment. Glassy texture, as the name implies, is that of glass or slag and has no definite minerals. It results when a molten magma is so quickly chilled that the minerals have no opportunity to form. Porphyritic implies larger crystals, well formed or corroded and rounded, embedded in a more finely crystalline, or even in a glassy "ground-mass." There may be several sizes and kinds of these crystals, and because of their prominence in the rock they are called phenocrysts, *i. e.*, apparent crystals (Phanerocryst is better etymologically). A granitoid or granular texture has the component crystals all about the same size, and very seldom possessing their own crystal boundaries. Strictly speaking, there is no groundmass in granitoid rocks. Sometimes from a local abundance of mineralizers (as later explained), granitoid rocks have small cavities into which the component minerals project with well bounded crystals. Such are called *miarolitic.*

Textures in igneous rocks are due to several factors that have influenced the development of the magma during its consolidation. The most important are chemical composition, temperature, rate of cooling, pressure and the original presence of dissolved vapors called mineralizers. The fusibility varies with the *chemical composition.* The most acid or siliceous magmas, *i. e.* those with 65–75% SiO_2 are least fusible. When molten they are viscid and ropy. The fusibility increases with the decrease of silica down to the basic rocks with 40 to 50% SiO_2. The ultra-basic rocks which graduate into practically pure bases, as in some rare, igneous iron ores are less fusible. This statement that acid rocks are least fusible often puzzles a student who is familiar with blast furnace practice and the composition of slags, in which the most siliceous are re-

garded as most fusible, but slags themselves as a comparison of analyses will readily show are to be paralleled with basic rocks. The importance of the fusibility as regards textures lies in the fact that the highly siliceous quickly chill, become ropy and freeze. They therefore especially yield glasses. The easily fusible remain fluid to lower temperatures, crystallize out as minerals to a greater degree and seldom yield glasses. They flow farther from the vent and tend to develop the porphyritic or even a variety of granular texture. The influence of *temperature* has been partly outlined in speaking of composition, but it will readily appear that in its progress to the surface a basic magma might stand for a considerable period at a temperature of fluidity, whereas an acid magma in the same situation would consolidate. The *rate of cooling* is important. Cooling magmas tend to break up into minerals. As a general thing it requires a very quick chill to prevent their formation. Hence it is that even volcanic glasses which appar to be perfect glass to the eye are shown to be full of dusty, microscopic minerals under the microscope. Volcanic glasses are chiefly found on the outer portions of flows or dikes, but instances are known where sheets of them are very thick, as at Obsidian Cliff in the Yellowstone Park. The common experience with lavas is that certain crystals develop to notable size, it may be an inch or more in diameter, while the magma stands beneath the surface, in circumstances favorable to their formation. These are then caught up in the moving stream and brought to the surface or near it where the final consolidation takes place and fixes them in the so-called ground mass. A quick chill makes a fine-grained groundmass when not a glassy one, a slow cooling yields one more coarsely crystalline, but in the final cooling or consolidation at or near the surface, crystals are seldom if ever developed of a size commensurable with those formed in the depths. By this process of partial crystallization below and final consolidation on the surface, the porphyritic texture is almost always developed, but in strict accuracy it should be stated that cases are known where phenocrysts appear to have formed in lavas after coming to rest. Magmas also flow to the surface with no phenocrysts (or "intratelluric" crystallizations) and then consolidate not as glass, but as finely crystalline aggregates, practically all groundmass.

Pressure, such as is developed upon a magma deep within the earth or during its passage to the surface is thought to exert an

influence upon the formation of many phenocrysts and to be necessary for their development. *Dissolved vapors*, such as steam, hydrofluoric and boracic acids are also important factors. Acidic magmas are more generally provided with them than basic, and where locally abundant they lead to variations both in the mineral composition and texture at different places in the consolidated rock. They may prevent the development of glass, and cause a sheet such as Obsidian Cliff, in the Yellowstone Park, to present alterations of glassy and stony layers, the latter being formed of microscopic crystals.

A word should be added about the chemical composition of rocks and about the interpretation of analyses before the rocks themselves are taken up. The analyses are reported in percentages of oxides, for the most part, and these are arranged in the following series, SiO_2, Al_2O_3, Fe_2O_3, FeO, CaO, MgO, Na_2O, K_2O, H_2O. In order to have anhydrous materials, it is customary to ignite and determine loss on ignition. This loss includes both H_2O and CO_2 and where large throws uncertainty over the relations of the elements left behind, because of the evident advance of decay. Small percentages of other oxides are quite invariably present and in refined work are determined. These are TiO_2, MnO, NiO, BaO, SrO, S, Cl, P_2O_5, Li_2O, and even rarer ones. They are however always in very small quantity. We often recast an analysis, by dividing, as in the determination of a mineralogical formula, each percentage by the molecular weight. We thus get numerical molecular ratios which indicate the relative numbers of individual molecules and enable us to draw conclusions as to the way they are combined with one another in the component minerals. Variations in chemical composition entail variations in resulting minerals, but it is also true that the same magma, if consolidating under different physical conditions of heat, pressure, etc., at different times may yield somewhat different minerals, for instance, hornblende instead of augite, or vice versa. A study of analyses soon makes one more or less familiar with the minerals that would necessarily result. The more important points are the amounts of silica, of the alkalies and alkaline earths, of iron oxides and of alumnia. For instance, as a rule only magmas high in SiO_2, yield quartz, for otherwise it would combine with the bases. Much K_2O is necessary for an orthoclase or leucite rock, but much Na_2O for one with nepheline. MgO in relatively large amount is

required to yield olivine or an orthorhombic pyroxene, and when feldspars drop away and rocks become very basic we expect high CaO, MgO, FeO, Fe_2O_3, and low SiO_2. In rocks tested as building stone, the significance of sulphur is important and very little should be present, for it indicates pyrites. It should never reach 1 %.

The specific gravity or density of a rock is an important feature in its practical bearings. While it may in ice be less than 1, and in coals and certain carbonaceous deposits drop as low as 1.25, and in very porous sandstones reach 2.25, yet in the common rocks it is seldom below 2.50, and ranges from this to over 3.00. Granites are usually about 2.65, but basic rocks, rich in iron, attain to the higher limits, even above 3.0. Determinations are important in those rocks used for building purposes, and are expressed in pounds per cubic foot.

Of recent years we have come to regard molten magmas as essentially solutions of some compounds in others, and to appreciate that solutions do not cease to be such, even when the temperature is very high. It results from this that the crystallization of the minerals of an igneous rock takes place from the magma as this in its cooling successively reaches a point of saturation for the salt in question. The least soluble thus separate the earliest of all, and then the others in order; but as the pressure under which they rest is also a factor, and this is subject to variation, as indeed is the temperature during movement to the surface, one mineral's period of formation may overlap another's more or less. The order of formation will be determined by the laws of thermodynamics and necessarily the mineral that develops the most heat in crystallizing will be the first to develop. As a general rule, the relations of the minerals in rocks show that the earliest to form are apatite; the metallic oxides (magnetite, ilmenite, hematite); the sulphides (pyrite, pyrrhotite); zircon and titanite. These are often called the group of the ores. Next come the ferromagnesian silicates, olivine, biotite, the pyroxenes and hornblende. Next follow the feldspars and feldspathoids, nepheline and leucite, but their period often laps well back into that of the ferromagnesian group. Last of all, if any excess of SiO_2 remains, it yields quartz. In the variation of the conditions of pressure and temperature just referred to, it may and does often happen that crystals are again redissolved in the magma, or are re-

sorbed, as it is called; and it may also happen that after one series of minerals, unusually of large size and of intratelluric origin, have formed the series is again repeated on a small scale as far back as the ferromagnesian silicates. Minerals of a so-called second generation thus result, but they are always much smaller than the phenocrysts, and are characteristic of the groundmass.

It results from what has been stated that the residual magma is increasingly siliceous up to the final consolidation, for the earliest crystallizations are largely pure oxides. It is also a striking fact that the least fusible minerals, the feldspars and quartz, are the last to crystallize.

In the matter of the study and determination of a rock species, especially of an igneous rock, it is desirable to procure materials as fresh and unaltered as possible. If feldspars have all changed to kaolin and clay, and if ferromagnesian silicates are merely chlorite or serpentine, and if secondary quartz, calcite and the like have formed, it is very difficult if not impossible to draw correct or even well-grounded inferences. Rocks near ore bodies are very often of this character.

Bearing in mind these differences of texture and the causes of them, it is possible to group igneous rocks in such arrangement that they can be intelligently studied, and identified with a reasonably close approximation to the truth. It should be appreciated, however, that with finely crystalline rocks, whose components are too small for the unassisted eye, the microscope is the only resource, and with this as an aid much greater subdivision can be attained. The object here in view is to limit the discussion purely to the study without the microscope.

The scheme of classification of the igneous rocks has three principles underlying it, viz: texture, mineralogical composition and chemical composition. The textures are four, glassy, porphyritic, fragmental and granitoid, and the table is arranged from top to bottom so that they come in this order. The arrangement is adopted because it brings the glassy which are the simplest of all rocks at the outset, where they can be best taken up by the beginner. The rocks are arranged from left to right on a mineralogical principle, and chiefly on the basis of the predominant feldspar present, as is the usual custom. This also makes possible a general succession from those most acidic on the left to those most basic on the right, but while this is true for the extremes it is not

ACIDIC ← IGNEOUS ROCKS → BASIC

Glassy	Acid Glasses, Obsidian, Perlite, Pumice, Pitchstone.			Andesite Obsidian		Basic Glasses Scorias, Tachylyte Basalt-Obsidian.					
	Chief Feldspar Orthoclase			Chief Feldspar Plagioclase		Pyroxenes		Nepheline, Leucite	No Feldspar		Ultra-basic Rocks.
	Biotite (or Amph.) Hornblende (or Augite)			Biotite (or Amph.) Hornblende				A series of rare basaltic rocks	Augite (or Hornblende or Biotite)		
	+Quartz	−Quartz	Augite Nepheline or Leucite	+Quartz	−Quartz	−Olivine	+Olivine		−Olivine	+Olivine	Basic Segregations in normal Magmas.
Porphyritic-	Rhyolite (Quartz-Porphyry) (Quartz-Felsite)	Trachyte (Porphyry) (Felsite)	Phonolite (rare) Leucite-Phonolite (very rare)	Dacite (Porphyrite)	Andesite (Porphyrite)	Augite-Andesite Olivine-free Basalt Diabase	Basalt Dolerite Olivine-Diabase	with Nepheline Leucite, (seldom Melilite) one or all. Not readily distinguished from basalt without the microscope. Extremely rare in America.	Augitite not readily distinguishable from Basalt. Extremely rare in America	Limburgite	Meteorites
Fragmental	Rhyolite Tuffs and Breccia	Trachyte Tuffs and Breccia	Phonolite Tuffs and Breccia	Andesitic Tuffs and Breccias.		Basaltic Tuffs and Breccias.					Water.
Granitoid.	Granite (Pegmatite)	Syenite (rare)	Nepheline Syenite (rare) Leucite-Syenite (very rare)	Quartz-Diorite (Tonalite)	Diorite.	(Diabase) Gabbro Anorthosite Norite	(Olivine-Diabase) Olivine-Gabbro. Olivine-Norite	Theralite (extremely rare)	Pyroxenite	Peridotite	Ice.
						Gabbro Group.					
SiO_2	80-65%	65-55%	60-50%	70-60%	65-50%	55-45%		45-38%	55-40%	45-30%	30-0%

strictly so for intermediate points because dacites and quartz-diorites are far higher in silica than are phonolites and nepheline-syenites, and even than ilachytes and syenites. The general range of silica is indicated on the lowest line. At the same time the importance of the bases is not to be overlooked and subsequent tables of analyses are given so as to show the range.

The general and larger truths of igneous rocks are fairly well brought out in condensed tables of this character, although exceptional cases are known that would require its modification. But no attempt has been made to confuse the larger truths by mention of the rarer occurrences, for, as before stated, only ordinary examination is assumed in connection with this text. When rare and exceptional varieties are met they should be placed in the hands of a microscopical worker. It should also be appreciated in connection with the table that groups of rocks shade into one another by imperceptible gradations and that they are not marked off with the sharpness of ruled spaces. In general the glassy and porphyritic constitute the *lavas* or surface flows, dikes and laccolites, while the granitoid rocks are the deep-seated, or abyssal ones, but there are cases where the latter show porphyritic tendencies and others wherein the former shade into granitoid textures.

THE STUDY OF ARCHITECTURAL HISTORY AT COLUMBIA COLLEGE.*

BY PROF. WILLIAM R. WARE.

Here in New York we have made rather a specialty of Architectural History. We believe that a well educated architect ought to be sufficiently acquainted with the work of his predecessors to profit by their successes and failures, and that familiarity with good work is the best way of cultivating the good sense and good taste without which more good work is impossible. Moreover we have at hand exceptional advantages for historical study, which we cannot afford to neglect. Other things can be pursued with success, outside the schools. For Construction, even scientific con-

* This paper substantially in its present form was written for the Committee on Education of the American Institute of Architects, in answer to an inquiry as to our methods of teaching Architectural History. W. R. W.

struction, and for Design, even academic design, schools are a help, but as we daily see, their apparatus is not indispensable. For historical study, however, books, photographs, drawings and museums are necessary, and if our young men do not profit by these things while they are at school, they will probably never have another opportunity. It seems to us, therefore, proper to give an exceptional prominence to this study, proportionate to the exceptional advantages afforded by the Avery Library, the Willard Collection at the Metropolitan Museum, and the fifteen or twenty thousand drawings and photographs which we have ourselves gotten together.

Besides this stated instruction by text-books and lectures, we give our men accordingly separate exercises in Historical Research, Historical Drawing and Historical Designing.

I. *Lectures.* The instruction by lectures occupies three to four hours a week during the first three years. Ancient, Mediæval and Modern History take each a year, and each is accompanied by a parallel course upon Ornament. In the first year Reber's History of Ancient Art is used as a text-book, the students instead of reciting from it, preparing a written abstract or table of contents. This compels an intelligent study and analysis of the text, and at the same time leaves the time in the class-room free for lectures, which are illustrated by drawings, prints, photographs and diagrams, and by lantern slides. In the second and third years similar courses of lectures are given, French and German text-books, which are read in the class, taking the place of the Reber. By giving each man a separate page to learn, we are able to cover a good deal of ground, and the time spent in the recitation room is made interesting and instructive. Nothing is more improving than to sit with the text before one and listen while other people translate it. In this way not only do French and German technical terms become familiar but considerable facility is obtained in reading those languages at sight. The whole field of French and German architectural literature is thus laid open.

II. *Historical Research.* The work of Ancient History during the first year has to be conducted mainly by lectures and text-books, the class not having time for any extended study of the libraries and collections, even if they had sufficient technical knowledge and skill to pursue such investigations to real advantage. It is to the acquisition of just this knowledge and skill that the chief

part of their first year is necessarily devoted. But by the time they take up the Mediæval and Modern Styles, in the second and third years, they are well equipped to obtain the information they need by seeking it at its source. In these years, accordingly, such investigations play a conspicuous part. In both of them the problems in Design are discontinued during a chief part of the second term, and the afternoons are occupied instead by exercises in Historical Research.

The classes are divided into sections of six or eight, each of which spends a week or fortnight in studying up some special topic—such as Vaulting, Tracery, Domes, etc.—exploring the libraries and collections and presenting a written report or memoir embodying the results of their investigations. The topics are taken up by the different sections in turn, so that every student goes over the whole ground and makes the acquaintance of all the material, no portion of which is at any time overcrowded with students.

During the first three years of the course our students have thus gone over the field of Ancient, Mediæval and Modern History with as much thoroughness as the time at their command and their technical resources may permit. The stated instruction in these subjects is finished. But this is the case also with all the other subjects taught in the department, formal instruction in them being virtually concluded at the end of the third term.

By this arrangement, which is perhaps a novelty in places of learning, the fourth year is left quite free from lectures or recitations. The men give their whole time by day to problems in Design, to what may be called Atelier work, without interruption. Their evenings throughout the whole year are devoted to historical study. As the College library, including the Avery library, as well as the books and photographs belonging to the Department of Architecture, are accessible every evening until eleven o'clock, and the Metropolitan Museum is open twice a week until ten, every facility is afforded for the prosecution of this work. In order to make the most of these appliances, every student of the fourth-year class and such of the Special Students (who are of similar grade being received only in advance standing), prepare once a month, under the name of Advanced Architectural History, an original paper. This he illustrates by drawings, prints and photographs, and reads to the class. All this affords an almost unexampled opportunity for serious work in the historical field.

To this study of the records we have added, this year and last, a study of the monuments themselves, such as our immediate environment permits. Trinity Church and the City Hall, built fifty and a hundred years ago, seemed to present historical examples well worthy of attention, both from their intrinsic excellence and from their being somewhat remote in style and manner from what is now customary in civil and ecclesiastical buildings. Both were sketched and measured in every part and carefully drawn out to scale, many of the details being drawn full size. Though undertaken mainly as exercises in architectural draughtsmanship, in preparation for the work in design, in order to give the students a sense of scale and materials, so that designs might hereafter recall to them the real effect of real things, this work and the studies in more nearly contemporaneous history that have followed it, deserves to be mentioned among the measures taken to secure a more intelligent and workmanlike comprehension of the monuments of the past.

Besides the work done in term-time, every student is required to prepare, during the vacation as part of his Summer work, lists of the principal events and of the principal persons that figure in the historical periods he is to study during the ensuing year.

III. Historical Drawing. During the First Year the class spend an hour a week in making drawings and tracings illustrative of the Ancient History they are studying. In the second and third years, they prepare during the second term large scale drawings rendered with the pen, pencil or brush, illustrating the points in regard to Vaulting or Tracery, Domes or Towers, Roofs or Ceilings, that may from week to week form the subject of their written reports. These reports are criticised and corrected and then are read to the class by their authors and the drawings shown. These classes, in fact, in a small way, lecture to each other, thus acquiring skill and confidence in preparation for the more formal exercises of the fourth year.

IV. Historical Design. These lectures and these researches and the drawing and writing to go with them, suffice to give the student a fair knowledge of Historic precedents, a knowledge which he shares with the historian, the critic and the connoisseur. It is a knowledge of their external aspect, and of the relation of cause and effect in which they stand to each other and to the social and political institutions, and the traditions and fashions of

their day, and to the conditions of time and place, and of material and labor, that have helped to mould them. But these studies take little cognizance of what was the prime factor in the production of these works of art, the fertile and ingenious mind of the old workman himself. All these facts of his environment, which are so interesting to us, and which present themselves so conspicuously to our minds, as the main elements of the situation, were to him simple matters of course. He did not think of them. They had no part in the reasoning which determined his action, an action which was determined as we may believe, not by any process of reasoning from recognized principles, but by simple considerations of good sense and good taste. Of most of the influences which seem to us to have been so powerful he was as unconscious as of the air he breathed, and the rest he felt only as he may have recognized the limitations under which he worked. Even the logical and esthetic principles which underlay his work and, as we can now see, largely controlled it, were for the most part, as always happens with the skilful workman, only half revealed to him.

It is by no means clear indeed how far these considerations entered even unconsciously into the mind of the designer. It is easy to over-estimate their real influence and to overlook the fact that what is really the most potent agency in determining the form of a work of art is the purely artistic considerations of grace of line and harmony of proportion, and that these are much the same in all ages and under all conditions. It is difficult to enter into the feelings of antiquity or of the Middle ages in regard to Religion, Government, Society and Natural Science. The modern man is a different creature from the man of that day in all these relations. But the artists of all ages are brothers of the same family. While accordingly it is difficult to make the study of history of practical service in those fields, it being hardly possible to understand the conditions well enough to glean from them examples pertinent to modern needs, the history of art is more intelligible and more serviceable. Its monuments, if studied from the point of view of the men who made them, are full of meaning, and that point of view is not altogether impossible of attainment. If this were not so, the study of architectural history would have no more important place in his school of architectural design, than has the study of archæology. It would be curious and interesting, but of no immediate service.

For what occupies the attention of architects of all times is, as has been said, the single question how to do the work in hand in a sensible and agreeable manner. The way for us to understand why the men of other times answered this question in the way they did, and thus to enter into the real understanding of the results, is to put ourselves as far as possible into their places, and to set before ourselves not their achievements, as examples to be classified, arranged and comprehended, but the problem they had to solve and the conditions which controlled their solution of it.

It is under this aspect that Historical Architecture is presented to our students, in their exercises in historical design. We exhibit to them the architecture of the past as a series of problems just as it appeared to the builders of its own day, showing it not as it looks from the outside, to the historian and critic, but as it looked from the inside, to the architect who designed it. We hope thus not only to give our men a clearer insight into the real spirit and character of the masterpieces that have come down to us, by bringing to view the ideas and considerations which really influenced their designers, but at the same time to exercise them in the practical application of those same ideas. We hope thus to develop the same good sense and good taste, the same readiness of invention and happy ingenuity to which those masterpieces are due.

The exercises themselves may be described as a species of design by description or by dictation. The attempt is made, by indicating the conditions under which a given piece of work was executed, to present to the student the same problem that the workman of old was called upon to solve. The student can then compare his own solution of it with the one that has come down to him, thus receiving correction and guidance in his work from the hand of the master. It is plain that the special excellencies of the original monument are likely to reveal themselves with fresh distinctness and to find special sympathy and appreciation in the mind of one who has striven, however unsuccessfully, to solve the same problem.

An example or two taken from widely different fields will suffice to illustrate this. In studying vaulting we once got so far as to understand how oblong vaults were thrown across a nave, while square vaults covered the aisles. A class of fifteen or twenty students were then asked to find out how a semi-circular or polyg-

onal apse could be added to a choir roofed on this system. After a couple of hours I found that they had worked out, among them, all the five solutions of this problem, which, in the Middle Ages, it took one or two hundred years to develop. This was very encouraging. At another time they were given a somewhat minute description of four Pilaster capitals from Blois or Chambord, and they made thumb-nail sketches on the spot according to their interpretation of the description. The next day photographs and drawings of a dozen or twenty other such capitals were given them, so that they might understand the fashion of the time, and they were told to draw out their sketches on a larger scale. The result was fifteen or twenty sets of capitals, all showing the same four motives, but differing in a most interesting way, according to the personal differences of taste and skill on the part of the designers.

On another occasion the first-year class, after their studies in Egyptian and Assyrian architecture, made a dozen or twenty restorations of Solomon's Temple, according to the description in the Book of Kings. The designs they produced showed considerable fertility of invention, especially in the drawings for Jachin and Boaz, and the whole series together seemed to be quite as creditable and as reasonable as most of those which have from time to time been put forth by the learned.

During the present year the first year men, before they had been two months in the School, made from dictation an almost equally successful restoration of an Egyptian palace, as described by Maspero and Perrott.

It is an obvious variation of these exercises and a great extension of their usefulness to let the students write the descriptions themselves, then exchange papers, and then interpret each other's texts as they best can. It constantly happens, when both description and interpretation are careful and scholarly, that the result looks like a copy of the photograph or drawing from which the dictation was made. It is surprising and instructive indeed to see how much of the spirit and charm of an original may be preserved in spite of considerable changes of proportion and detail.

This practice in Historical Design we believe to be founded on sound theoretical principles. To regard a work of art as far as possible from the point of view of the artist is indeed the first principle of fair and intelligent criticism. To foster the individuality and per-

sonal initiative of a pupil by bringing authority to bear upon him in the way of suggestion at the beginning of his task and correction at the end of it, rather than of guidance and control during the process of his work, is the first principle of intelligent teaching. Moreover, the results, so far as we have gone, have justified the method. We have indeed employed it hitherto mainly as a matter of experiment as favorable circumstances have permitted it; but every year we use it to a greater and greater extent, and it is gradually acquiring a recognized place as an integral portion of our work.

A considerable step in this direction was taken last winter when we undertook to apply this method of Design by Dictation to the study of the architecture of the Renaissance by the second-year class. We began with doors and windows, giving out a list of the elements that entered into their composition—such as architrave, frieze and cornice, arches and imposts, pediments, pilasters, pedestals and ballisters, consoles, brackets, modillions, sills and thresholds—forms with which they had already become familiar in the study of the Orders. They were told to design a dozen windows, ranging from the most simple they could conceive to the most complicated, making sketches in the class at as small a scale as possible and drawing them out afterwards to a quarter-inch scale, approximately. These were criticised from the point of view of proportion and elegance, as they were studied with tracing paper. As a second lesson, several examples of doors and windows from Letarouilly's Rome were dictated in detail and the resulting interpretation compared with the originals. Finally we were fortunate enough to discover that there was a certain type of doorway of which we could find no example, namely, a doorway furnished with large consoles, after the fashion of Vignola's classical example in the church of San Damaso, in the Cancellaria, but with a Mutulary-Doric frieze and entablature. This was a highly successful experiment. Half a dozen of the class devised forms of console quite in keeping with the triglyphs and mutules, thus adding, it would seem, a new feature to the resources of the classical architect.

This was followed by similar exercises in the treatment of vaults and ceilings, of wall surfaces external and internal, of spires, stairways and other of the larger features. All this was in preparation for the problems in Design which occupied the third and fourth years.

We are this winter extending this method to still more elemen-

tary work in the study of the Orders themselves, and to more advanced work in the study of Planning.

These exercises are indeed a part of the course in Design, but the principle is the same and it can easily be applied, as the first cited examples have shown, to the study of the historical development of style. Every step in the evolution of Gothic architecture was taken by varying the procedure which at any moment happened to be in vogue, in accordance with some suggestion of improved construction of ornamentation. The most successful variations survived by a process of natural selection. It is perfectly practicable, as we found in the case of apsidal vaulting for these suggestions to be made to the student, so that he may breathe in the precise footsteps of the Free Masons, forestalling in fact in his own experience the revelations of the text-book. This Design, by anticipation, as it may be called, will, we hope, come to play a valuable part in our strictly historical studies as a sort of obligato accompaniment to the lectures on Architectural History, from the time of the Pharaohs to that of the Georges.

The local peculiarities that distinguish the styles of France from those of Italy, and those of Spain from those of Germany and England, are obviously amenable to this treatment. It is after all merely a special application of the principle that it is better for a student to find things out for himself than to be told them. It makes him answer the question, the most searching of questions, "How would *you* do it?" The artist, whose function is a creative one—whose business it is to do original work, yet who must be well versed in all the experience of his kind, profits greatly if he can gain this erudition through the exercise of his active and inventive powers, instead of assuming, during the long time necessary for its acquisition, a passive and merely receptive attitude. The architect, especially, is what the Greeks call the poet, and what the Scots call him too, a maker.

It is not of course every student who can rise to the full height of this argument, though it is true, as Mr. Emerson contends, that every man may be a man of genius as far as he goes, and that whatever spark of originality he has, should be sacredly cherished. But some men, at least, in every class can profit by these exercises to the utmost, and these should not be deprived of the experience. Others may follow haltingly, and may after all have to be shown what they had not the wit to discover. But they are no worse off

if told things at last than they would have been if told them at first. Indeed they are better off, for the sense of baffled endeavor makes one specially appreciative of assistance. The information comes as a "felt want," to a mind disciplined to receive it. The main trouble in getting such men to receive new information is that they do not in general, feel that they want it.

Whether this long course of historical study and investigation, occupying a large portion of the student's time during four years, will materially contribute to the result anticipated in the Committee's Report of last year, we do not know. The committee expressed the hope that if the study of the historic styles were systemized and coördinated in the schools, "such an effective concentration of intelligent effort might aid in developing a system of architectural forms that should be nationally characteristic and should be more accurately adjusted to the expression of modern American life" than those now in vogue. We do not feel that it very much concerns us to exert ourselves to any such end. We do not see that we have any cause to map out the future, to cast a horoscope, or to attempt to influence events toward issues indicated by any Astrologist that can be devised. We distrust the science which, in our present state of ignorance, undertakes to foretell or to control the Architectural weather. All we can be sure of is that the architecture of the future will be good or bad, noble or ignoble, fair or foul, according to the personal character and professional prowess of the men who have it in hand. All we can undertake to do is, if possible, to inspire the young men who come under our hand with a certain measure of good sense and good taste, teaching them by precept and by the example of history, that in art as in life, temperance and refinement of conduct come from firmness of mind and elevation of spirit, and that these are the only sure means to those ends.

Here historical studies pursued as we aim to pursue them may be of inestimable service. They not only train the active and artistic powers, but by giving, as we hope, a keener appreciation of the excellence of excellent things, refine the taste and fortify and confirm the judgment. They promise to be the most efficient safeguard against the wild and wanton demonstrations which both in Europe and in this country have so often borne witness to the native force and vigor of an undisclipined and unchastened imagination.

I cannot help thinking also that this discipline is calculated to calm the anxieties of those who fear that too prolonged courses of academic study may enervate the powers instead of stimulating them, and, as in a hotbed, bury or burn out all seeds of originality through too rich a culture. I fancy that these fears have in general but little foundation, and that it is not through over-education that talents are lost to the world and fail to bring increase to their owners as much as through their lying neglected, or, as sometimes happens, being too carefully tended by their possessors lest their original brightness should be tarnished. Still it is true that in the conduct of life, and especially in the practice of the arts, which is but a finer kind of living, it is the special personal quality, the spark of individuality and originality which lights every man who comes into the world that has intrinsic value, and through the risk of extinguishing the flame in too strong a draught may be exaggerated, it is not possible to exaggerate the importance of fostering it and magnifying it. There is no knowing what fire it may not kindle. "If ever you have a valid idea," I once heard Professor Pierce exclaim, "however slight and unimportant it may seem to be, cling to it, cherish it, develop it, and some day you may awake and find yourself immortal!"

As society grows older, and the mass of the traditions and accumulated eruditions which are the tools of civilized man becomes more cumbrous and unmanageable, it is constantly more and more difficult to satisfy the legitimate requirement that what is done shall embody the excellencies which have stood the test of experience, and at the same time meet the equally legitimate cry for new manifestations and materializations of the spirit. For in art as in the law, what is customary is the thing to do; nothing pleases but what suits our habitual preferences and prejudices, natural and acquired. Yet we are always seeking some new thing and every familiar dish must be spiced by some variation in its composition. This is the impossible task set to the architect who builds to please. The satyrical knave must blow hot and cold with the same breath, be at once original and correct, and manage somehow to stamp the current coin with a new face by a single masterful blow. I cannot but think that a method which at every turn, and even in the acquiring of necessay information, appeals to a student's creative and inventive powers must have a tendency to stimulate and strengthen them and so to practice them in

felicitous achievement that he may haply in a happy moment strike this masterful stroke.

In the battle of life the main line must of course be held by the disciplined and the obedient, by the regulars in the trenches. But the advance depends upon the skirmishers, the independent thinkers, who venture not without method into unfamiliar fields. The actual world, that is and has been, tends daily, as it is better known, to make his ideal world which the artist lives to create more and more impossible. The only way to prevent him from being discouraged in the pursuit and abandoning himself to that imitation which, as Mr. Emerson says, is suicide, is to give him skill and confidence in the use of his inventive faculties by practicing him in their use from the beginning.

BOOK REVIEWS.

Missouri Geological Survey, Volume VI., Lead and Zinc Deposits. By ARTHUR WINSLOW, assisted by JAMES D. ROBERTSON. In two parts, each a large volume. Jefferson City, 1894.

This long expected report appeared the past summer, although the title page bears the date 1894, some delay having ensued for lack of appropriations. It is the culmination of several years of work in the Missouri lead and zinc mines. The work was begun while Mr. Winslow was the State Geologist, in coöperation with the U. S. Geological Survey. W. P. Jenney was detailed by the latter and James D. Robertson was assigned to him as assistant by Mr. Winslow. As the result of Mr. Jenney's work, we have the well-known paper read at the Chicago meeting of the Institute of Mining Engineers in 1893. Subsequently to the cessation of Mr. Jenney's field work in 1891, Mr. Winslow took the subject up and the result is the two volumes before us. Part I. of 387 pages is a very thorough historical, geological, statistical and metallurgical review of the two metals in all ages and countries, and is a very valuable and complete work of reference. Part II. describes the mines of Missouri in particular. A historical sketch is first given; next the physical geography of the mining districts is described; next the general structural geology of the State, and then the geological history of southern Missouri. A discussion of the ore deposits follows, and a source of the metals is advocated that is the last of the three possibilities and the one that had not been previously urged. Whitney as much as forty years ago advanced the view that the metals had been precipitated contemporaneously with the containing strata from the ocean and that they had subsequently been concentrated. He was corroborated by Chamberlin twenty years later. Percival and Jenney advocated the introduction by uprising solutions from below. The only remaining method is that supported by Winslow, of descension from above. By analysis of samples of rock, Winslow proves the general presence of the two metals in the Archean crystallines, and in the Paleozoic sedimentaries. The view is then advanced that in the long subaërial decay of these Paleozoic strata the lead and zinc have leached downward and have found a resting place as the case may be in the shattered cherts, or the gash veins or the dolomites in which last named they have replaced the original rock. The ore bodies are hard problems, and objections can be easily urged to each of the three views.

The report concludes with local details of all the mining districts, and with a fairly complete bibliography. It is much the most complete work extant on lead and zinc and deserves high praise. We think, however, that in so detailed a work the local ore dressing processes ought to have received attention. As it is, they are scarcely mentioned, and yet the success of mining depends upon them to a very great extent. At least, the two or three papers on the subject should have been cited, and notably, the discussion by Professor Munroe in the Trans. Inst. Min. Eng. XVII. 659, Oct. 1888. J. F. K.

The Mineral Industry, Its Statistics, Technology and Trade in the United States and Other Countries from the Earliest Times to the End of 1894. Vol. III. Being the Statistical Supplement of the *Engineering and Mining Journal.* Edited by RICHARD P. ROTHWELL. Published by the Scientific Publishing Co., 253 Broadway, New York. 8vo., 770 pages. $5.00.

This large octavo volume, bound in red covers, immediately attracts attention, and its contents fully justify its brilliant binding. This volume supplements and greatly increases the vast amount of valuable information which appeared in Vols. I. and II., and with them forms a collection of statistics as to history, occurrence, methods of mining, treatment of ores, costs, uses, prices current etc., of inestimable value to the engineer, the chemist, the metallurgist, the buyer and seller of mineral properties, and, in fact, to all interested in the development of the mineral production of the country.

The intention in the preparation of the work has been to collect and put into convenient form all the reliable statistics of the mineral industry of the world, to collect promptly and accurately the mineral statistics of the United States, and to photograph, as it were, the condition of the industry from year to year, bringing out into boldest relief that information which has the greatest practical value on the development of the industry and which is not always easily accessible. The accumulation of the necessary data concerning the past and the elucidation of the conditions which affect the growth and well-being of a great industry constitute a vast undertaking. The enormous amount of labor and care involved in the preparation of this great work is appreciated when we consider that its index includes 12,000 distinct titles. The volumes already issued contain almost all the statistics of record, in all the countries of the world, concerning the production, imports, exports and consumption of all the minerals and metals. They give also the best methods of production, the uses and properties of nearly all the minerals and metals, and in most cases the economic questions of cost of production as well.

The following minerals and metals and their products are treated, generally with adequate thoroughness:

Abrasive materials; alum; aluminium; antimony; arsenic; asbestos; asphaltum; barytes; bauxite; bismuth; borax; bromine; cadmium; cements; the chemical industry, with the latest electrolytic and other processes applied in America and Europe; chrome iron ore and its products; clay and the clay industry; coal, with graphical tables of production, consumption per capita, production per man employed, costs, markets, coal mining machines and their work; copper production, consumption, markets, improvements in copper metallurgy, all the electrolytic refining processes, present practice in copper concentration and extraction throughout the world; copperas; cryolite; feldspar; fluorspar; gold and silver; graphite; gypsum; iron and steel; advances made in iron and steel metallurgy; lead, distribution and production of lead in all countries; recent improvements in the treatment of argentiferous lead ores; magnesite; magnesium; manganese; marls; mica; nickel; onyx-ozokerite; peat; petroleum, its production, refining, markets, etc.; phosphate rock; phosphorus; precious stones; pyrites; quicksilver; the rare elements; their occurrence and production (barium, boron, calcium, cæsium, cerium, chromium, columbium, didymium, erbium; gallium,

germanium, glucinum, indium, lanthanum, lithium, manganese, molybdenum, osmium, palladium, potassium, rhodium, rubidium, ruthenium, scandium, selenium, silicon, strontium, tantalum, tellurium, thallium, thorium, titanium, uranium, vanadium, ytterbium, yttrium, zirconium); salt; slate; sodium; sulphur; talc and soapstone; tin; tungsten; stone, including brownstones, limestones, marbles, lithographic limestone, flagstones and all other building stones; zinc.

Statistics of countries: Australasia, Austria-Hungary, Belgium, Canada, other British colonies, Chili, France, Germany, Greece, Italy, Japan, Norway, Portugal, Russia, Spain, Sweden, Denmark, Egypt, Holland, Roumania, China, Switzerland, United Kingdom, United States.

Assessments by mining companies; dividends paid from 1884 to 1894.

A feature of great value is the introduction of articles by competent specialists in the different chapters bearing on the subjects. These technical articles in the form of monographs not only give statistics but present a comprehensive discussion of the great industries, either as a description of the development of a process from its infancy or as a discussion of a group of industries bearing upon the recent progress in mining metallurgy and chemical industry, thus bringing up to date all the technical text-books. These admirable papers give an additional value to a work which in itself possesses a foremost place in the publications of its class.

The only criticism of moment is that in some cases the subjects which were prepared by specialists in Vols. I. and II., and which formed a main feature in the value of the work, have not been brought up to date by them or by other specialists. It is evident that a specialist would have a better knowledge of the progress of his subject than others.

The most striking among the special articles are "Some Recent Improvements in the Metallurgy of Copper," by E. D. Peters, Jr.; "Recent Improvements in the Treatment of Argentiferous Lead Ores," by H. O. Hofmann; "The Amalgamation of Free Milling Gold Ores," by Lewis Janin, Jr.; "Electrolytic Copper Refining," by Titus Ulke; "Alum and Sulphate of Alumina," by John Enequist; "Some Improvements in the Manufacture of Sulphuric Acid," by W. H. Adams; "Electric Methods of Alkali Manufacture," by T. Ulke.

The are other special articles as follows, viz: "Chemical Industry, its Progress in 1894;" "Corundum Mining and Concentration," by Titus Ulke; "Underground Practice at the Mines of Butte, Mont.," by R. G. Brown; "Aboriginal Metallurgists," by James Douglas; "Phosphates of Tennessee," by Lucius P. Brown; "Lake Superior Iron Ore," by J. P. Channing; "Distribution of Silver in Lead Bullion and the Different Methods of Sampling," by A. Radt; "Treatment of Pyritiferous Ores Containing Copper and Nickel," by T. Ulke; "The Zinc Mines of Southwest Missouri and Southeast Kansas," by J. R. Holibaugh; "Electrical Transmission of Power in Mining," by Timothy W. Sprague; "Electroplating," by T. Ulke; "Progress in Ore Dressing in 1894," by Robert H. Richards.

Year by year the immense value of the mineral products of the country becomes more and more evident. The following table compiled from that given on p. 5 presents the mineral production of the United States for the year 1894: The subdivisions of the various headings as given in the table have not been strictly adhered to, the amounts and values being grouped together and so reported.

Mineral production of the United States, 1894.

Products.	Quantity.			Value at Place of Production.
	Customary Measure.		Metric Tons.	
Non-metallic.				
Abrasives	Short tons.	43,454	39,412	$605,884
Alum	"	72,000	65,304	2,160,000
Antimony Ore	"	165	150	9,075
Asbestos and talc	"	60,894	55,231	801,642
Asphalt	"	4,198	4,080	75,654
Bituminous rock	"	34,199	31,018	148,120
Barytes	Long tons.	23,758	24,141	95,032
Bauxite	"	10,732	10,908	42,928
Borax	Pounds.	13,140,589	5,962	979,841
Bromine	"	379,444	172	98,655
Cement	Bbls. 300 lbs.	8,633,455	1,174,531	1,080,644
Clay	Short tons.	3,400,290	3,084,040	4,236,054
Coal, Anthracite	"	52,010,433	47,183,345	80,879,404
Coal, Bituminous	"	117,950,348	106,953,311	103,842,467
Coke	"	8,495,295	7,706,846	12,654,558
Cobalt oxide	Pounds.	6,550	3	8,843
Copperas	Short tons.	14,897	13,511	104,100
Copper Sulphate	Pounds (est.)	60,000,000	27,215	2,016,000
Chrome Ore	Long tons.	2,653	2,697	35,125
Feldspar	"	23,280	23,655	116,400
Fluor Spar	Short tons	9,000	8,165	64,000
Graphite	Pounds.	1,005,846	499	35,941
Gypsum	Short tons.	287,517	260,834	849,925
Lime	Bbls 200 lbs. (est.)	56,750,000	5,148,326	28,375,000
Magnesia	Short tons.	1,370	1,243	4,864
Manganese Ore	Long tons.	11,735	11,924	74,899
Mica	Pounds.	839,400	381	37,060
Monazite	"	750,000	340	45,000
Natural Gas				11,000,000
Paints	Short tons,	148,898	134,089	10,864,311
Petroleum	Bbls. 42 gals.	48,527,336	6,788,974	40,762,962
Phosphate Rock	Long tons.	952,155	967,485	2,856,455
Marls	"	225,000	228,622	607,500
Precious Stones	"			250,000
Pyrites	"	107,462	109,192	466,466
Salt	Bbls. 280 lbs.	11,502,975	1,460,946	5,396,956
Silica, Sand & Quartz	Long tons.	315,531	320,610	347,951
Slate	Squares.	3,432,576		3,050,837
Limestone flux	Long tons.	3,544,393	3,601,458	2,126,636
Stones, building, etc	(est.)	40,116,508		30,000,000
Total Non-metals				$353,760,877
Metals.				
Aluminum	Pounds.	817,600	371	490,560
Antimony	Short tons.	220	205	39,200
Copper	Pounds.	353,504,314	160,392	33,540,489
Gold	Troy ounces.	1,923,619	*59,824	39,764,708
Iron, pig	Long tons.	6,657,388	6,764,572	71,966,364
Lead, N. Y. value	Short tons.	160,867	145,906	10,585,048
Nickel, fine	Pounds.			
Mercury	Flasks, 76½ lbs.	30,440	1,056	1,095.840
Silver, com. value	Troy ounces.	49,846,875	*1,550,387	31,403,531
Zinc Spelter	Short tons.	74,004	67,135	5,209,882
Total Metals				194,095,622
Est. products not specified				5,000,000
Grand Total				$553,356,499

* Kilograms.

In addition to these facts the table gives the itemized production in 1893 for the purpose of comparison. Summing up, the result of the comparison of 1893 and 1894 shows a moderate decrease in production with a much larger proportional decrease in value or prices. The prevailing conditions under which the year closed were far more favorable than those which existed at the beginning, and the year 1895 has already begun to show a great improvement over its predecessor. J. S.

The Constructor, a Hand-book of Machine Design. By F. REULEAUX, Translated by Henry Harrison Suplee, Philadelphia, 1893.

The Konstruktor of Prof. Reuleaux has been a classic for the machine designer ever since its first presentation in the German to the profession of engineering. The field of mechanical construction is so wide and the sciences which contribute to it so various that the difficulty is usually in choosing what shall be omitted, rather than in selecting what shall be included, and it is further a considerable difficulty of such an undertaking to decide upon the system or method, according to which the different discussions shall be grouped.

The translation which Mr. Suplee has made presents Dr. Reuleaux's 4th edition, bearing date of 1889 to the English Public, with additions and revisions made by the author while the translation was in progress, but the work of the translator has been not only the routine of his problem, but by suggestion, by incorporating American methods and practice, and particularly by the transformation of the formulas and tables into the English units, he has done a personal service and has made the book a monument of painstaking and exact professional work with which his name will be most creditably connected.

In the preface to the 4th edition Prof. Reuleaux gives a condensed summary of the fundamental Theoretical Kinematics with which his name has been identified and which has done so much to bring into intelligible relations many forms of transmissive apparatus. The principles of Prof. Reuleaux's system were first presented to his students in 1862, and later in book form in 1875, and its translation by Prof. A. B. W. Kennedy in 1876 has remained a standard for all students of these subjects. It was Prof. Reuleaux who created the term "Pairing of Elements" and drew from them the consequences which follow, when the motion of such pairs is restrained in one direction or another, and more or less completely.

Applied Kinematics shows how the motions discussed in the theoretical division are utilized in actual organs and brings out the point that many mechanisms, apparently very much unlike and using different organs, are really either similar or exactly analogous.

The work itself is a quarto of 300 pages, copiously illuminated with something over 1200 illustrations. The first two chapters are very properly devoted to a discussion of the mathematic and theoretical formulæ of the strength of materials and the resistance to different sorts of loading and strains.

The chapter on Graphostatics in its application to Dynamic problems is perhaps unique in breadth of application.

Section III. gives a discussion of Machine Elements, and extensive treatment of Riveting, Hooping, Keying, Bolts, Journals, Bearings, Axles, Shafting, Couplings, Cranks, Levers, and Connecting Rods.

This discussion occupies 16 chapters covering 126 pages, and there are very few of the conventional forms of machine parts, particularly as they have been made familiar by the German designers, which do not find place and discussion under their proper heading.

The transmissive machinery sections cover toothed and rachet gearings, ropes, belts and chains. The pressure organs which include elements using fluids, pasty substances and granular materials receive discussion in the next three chapters from pages 216 to 273, and the special problems connected with hydraulic transmissions and machinery, reservoirs and the like is conspicuously complete and full. The final chapter on valves brings out the analogy between the valve and the ratchet and concludes the descriptive part. The last section is Tables and Formulæ for convenient references, and a complete alphabetical index closes the whole.

It is difficult to speak with moderation of a work of this magnitude. In proportion as the difficulty is appreciated, it is the tendency of the reviewer to run into superlatives. There is no question, however, that every one connected even remotely with the designing of mechanical details will be very much helped by the possession of this as a book of references, and for the student it is a model of the professional method for the solution of problems, involving as its basis rigid scientific dependance upon fundamental laws, while the solution is conditioned with great sensitiveness by the application of common sense and experience to the results of theory.

Dr. Reuleaux has been called "a teacher of teachers," and an inspection of his Constructor shows the extent to which the epithet is justified by the facts; nor must the debt to Mr. Suplee be forgotten in the recognition of the author's greatness. F. R. H.

An Experimental Study of Field Methods, which will Insure to Stadia Measurement greatly increased accuracy. LEONARD SEEVAL SMITH. In Bull. Univ. of Wis., I., 101–145.

The increasing use of Stadia Measurements in almost all branches of surveying makes the appearance of a thorough discussion of the causes of error, and the best methods for the correction of same, in Stadia work particularly timely. The author first takes up the question of atmospheric unsteadiness, considering both lateral and vertical vibrations, and the effect thereon of the condition of the atmosphere at the time of making the observations.

The conclusions from the experiments made are, in general, that the maximum unsteadiness of the air comes, *not* during the hour when the air is at its maximum temperature, but rather during the time when the *difference* between the temperature of the air and the earth is at a maximum.

Following this the effect of "differential refraction" on stadia measurements is discussed, as deduced from a number of experiments.

The conclusions arrived at from a careful study of the results of these experiments applied to practical field work make the investigations of the author especially valuable to the practicing engineer.

In the past the main objection to the more extended use of the stadia in surveying operations has arisen from the comparatively large error which has heretofore been considered a necessary evil in this class of work.

When, therefore, it is proven, as in Mr. Smith's paper, that by the new method of field work and the determination of the "interval" value as advocated therein, a very large reduction is caused in the error incident to stadia measurements, the book becomes of much value to all interested in the development of stadia surveying. A. E. F.

Clay Industries of New York. By HEINRICH RIES. Forming No. 12. Vol. III., Bulletin of the New York State Museum. Pp. 97–262, many illustrations and a State map. F. J. H. Merrill, Director, Albany, 1895. Price, 30 cents.

Within the last five years people in general have awakened to the importance of our clay industries. New York for example up to the publication of this report had given them no official attention, although they amount to $8,870,000 yearly and are among the most important that are in operation. The industry of common brick was such an every-day affair as to excite slight comment. The report of the New Jersey Geological Survey on their clay industries, issued in 1878, has been for almost fifteen years practically the extent of our literature. It has fallen to Mr. Ries to be a pioneer in this field, and beginning with his graduation thesis at the SCHOOL OF MINES, 1891, he has developed this subject until now we have the bulletin before us in addition to an earlier paper on the stratigraphy of the Hudson River clays (Ann. Rep. N. Y. State Geol. for 1890); a very thorough one in the *Mineral Industry*, 1893; a still more extended one to appear in the next volume of the *Mineral Resources* published by the U. S. Geological Survey, and a number of minor contributions. During the same time work has been going on, as yet unpublished, by H. A. Wheeler, on the Missouri Geological Survey, and by Edward Orton, Jr., under the Ohio Geological Survey. While we write, Mr. Ries is engaged in judging the clay exhibits at the Atlanta Exposition, an engagement that is a gratifying recognition of his work.

The Bulletin begins with a sketch of the geology and geography of the clay deposits. They are of Quaternary, Tertiary and Cretaceous ages, but the first group is much the most important, the second has been long determined on Long Island, and the third is only developed on Staten Island and Long Island. On the mainland they are in basins and were probably formed in ponds or lakes, many of which were backed up by glacial ice. Along the Hudson they are estuary deposits and are buried in most cases under deltas. The several productive areas on Lake Champlain, Long Island and Staten Island are then further outlined, the others having been previously treated. General subjects introductory to descriptions of processes of manufacture follow. Detailed notes on individual yards, and a list of concerns engaged in the business conclude the work. Scattered through the pages are many analyses, which are the more welcome as there are few in print. Notes on the vitrified brick industry from shales are not lacking. In general the proof has been carefully read, but on p. 143, lines 4, 5 and 6, grain appears for gram. Many reproduced photographs are utilized as illustrations, which are mostly good, but the upper one on p. 132 leaves us a little uncertain as to the details.

Mr. Ries is to be congratulated on having—as the usual prefaces say—"filled a want that has long been felt" and on having done it well.

J. F. K.

Fourteenth Annual Report of the United States Geological Survey to the Secretary of the Interior, 1892–93. By J. W. POWELL, Director. Part I. Report of the Director. Part II. Geology—accompanying papers. Washington, Government Printing Office. 1893. 8°, 2v.

Volume I., of 321 pages, is taken up by the administrative reports of heads of divisions and other executive matters. The only general interest that it possesses lies in the fact that it sets forth the plans and policies of the Director and of the above officials. The second volume contains a valuable series of accompanying papers, viz:

1. Potable Waters of Eastern United States, W J McGee, pp. 5–47.
2. Natural Mineral Waters of the United States, A. C. Peale, pp. 53–88.
3. Results of Stream Measurements, F. H. Newell, pp. 95–155.
4. The Laccolitic Mountain Groups of Colorado, Utah and Arizona, Whitman Cross, pp. 165–241.
5. The Gold-Silver Veins of Ophir, California, Waldemar Lindgren, pp. 249–284.
6. Geology of the Catoctin Belt, Arthur Keith, pp. 293–395.
7. Tertiary Revolution in the Topography of the Pacific Coast, J. S. Diller, pp. 403–434.
8. The Rocks of the Sierra Nevada, H. W. Turner, pp. 441–495.
9. Pre-Cambrian Igneous Rocks of the Unkar Terrane, Grand Canyon of the Colorado, Arizona, Charles D. Walcott, with notes on the
10. Petrographic Character of the Lavas, Joseph Paxson Iddings, pp. 503–526.
11. On the Structure of the Ridge between the Taconic and Green Mountain Ranges in Vermont, T. Nelson Dale, pp. 531–549.
12. On the Structure of Monument Mountain in Great Barrington, Mass., T. Nelson Dale, pp. 557–565.
13. The Potomac and Roaring Creek Coal Fields in West Virginia, Joseph D. Weeks, pp. 573–590.

The first paper has popular interest but no geological importance. The second is an excellent summary of the country's mineral springs and will be often serviceable for reference. A list of the leading ones by States is included. The third paper has valuable data on the amount of flow in Western rivers, and on the Potomac, Connecticut and Savannah in the East. It will be an important contribution to irrigation in the West, and to our general hypsometric knowledge. The fourth paper is a most important contribution to the geology and petrography of the area discussed. It shows the great part played by laccolites in some of the best known Colorado mountains and the close parallelism that exists among them all in the character of the rocks. In the fifth paper Mr. Lindgren ably discusses the interesting gold-quartz veins of the Ophir district, Placer county, and draws some well based conclusions as to their method of origin. In the sixth paper Mr. Keith brings out a vast amount of new and important knowledge about the metamorphic and paleozoic belt that passes from Pennsylvania south through Hagerstown and Harper's Ferry, Md., and across West Virginia and Virginia to the Rappahannock River. Besides describing the local structural geology and its development, the paper includes an important contribution to the dynamic metamorphism of pre-Cambrian igneous rocks, both plutonic and volcanic. In the seventh paper Mr. Diller takes up the Tertiary changes

in that most interesting problem, the recent geological history of the Pacific coast. The ancient base levels are traced and many important conclusions are deduced which have a close connection with the auriferous gravels. Mr. Turner's paper (the eighth) presents an admirable review of the geology of the Sierras and adds greatly to our knowledge of their petrography. In the ninth paper Mr. Walcott describes the relations of the pre-Cambrian lava sheets to the other Algonkian terranes of the Grand Canyon, and gives detailed sections and views. Prof. Iddings identifies them as surface or submarine flows of basalt. In the eleventh and twelfth papers Prof. Dale extends the area covered by his previously published work in the metamorphic belt of the New York and New England border and especially in the latter, clears up the geology of a mountain famous alike for its geology and lovely scenery. Both papers are also important contributions to our knowledge of the mineralogical changes involved in the passage of sediments into schists and marbles. In the last paper Mr. Weeks describes, under the name of the Potomac basin, the important coal field that extends from Wellersburg, Pa., across Maryland into West Virginia, and that embraces the Cumberland or George's Creek coal of Maryland, and the Elk Garden and Upper Potomac coals of West Virginia. Analyses, sections and statistics are given. J. F. K.

The Production of Tin in Various Parts of the World. By CHARLES M. ROLKER. Advance excerpt from the Sixteenth Annual Report of the Director of the U. S. Geological Survey. 1894–1895. Part III. Mineral Resources of the United States. Calendar Year. 1894. Pp. 1–88.

It would appear from the above reference that the forthcoming annual reports of the Director of the Survey are to have a regular department devoted to Mineral Resources. This is to be warmly commended, both because to the general public, which is after all the Survey's real constituency, it affords material that is of value, and because it caters to the scientific public as well. Many friends of the Survey have viewed with regret in recent years the small prominence that this portion of its work has received, and have felt that it was a mistaken policy.

Mr. Rolker gives an admirable and concise review of tin ores, their geology, statistics and the expense of production the world over. The report covers much the same ground in many respects as that treated by Professor Ed. Reyer in his "Zinn, eine geologisch-montanistisch-historische Monografie," that appeared in Berlin in 1881, but Mr. Rolker brings the subject down to date, omits many theoretical discussions and makes especially prominent those points that are of importance in their practical relations. The geology of cassiterite is curiously uniform, wherever the mineral is found. Veins in or near granite or gravels yielded by them are its sources, whether it be in Cornwall, the Zinnwald, the Malay peninsula or Australia. The large part played by tin in the bronze implements of the ancients and even in prehistoric commerce give it peculiar claims to interest. Enormous attention has been devoted to tin mines in this country of late years, so much that the metal has even been a political factor, loudly heralded in recent campaigns. All our enterprises have as yet been without success, and some are instructive examples of extravagant folly. Mr. Rolker's dispassionate and truthful descriptions are timely and much to be commended. J. F. K.

Modern Copper Smelting. By EDWARD DYER PETERS, JR. Seventh Edition. Rewritten and greatly Enlarged. New York and London, Scientific Publishing Co., 1895. Price, $5.00.

The first edition of this work was published in 1887, and was favorably received by the leading metallurgists of the country; since then from time to time subsequent editions have appeared with more or less change of text until this, the seven th edition, which eclipses all others in the amount of revision and new material added. The work first appeared under the title "Modern American Methods of Copper Smelting," as the original matter was limited mainly to American practice. The latest edition is more general in character, as foreign practice is touched upon, and justifies the change in title to "Modern Copper Smelting."

The value of this work is greatly enhanced by the assistance given by specialists in the preparation of chapters on certain new methods of treatment, which have developed so rapidly during the past few years that no one man could pretend to possess an intimate knowledge of them all. These special chapters are "Pyritic Smelting," by Robert Sticht. "The Bessemerizing of Copper Matte," by H. A. Kellar, and the "Electrolytic Refining of Copper," by Maurice Barnett.

A brief synopsis of its contents is as follows:

Chap. I. Copper and its Ores.
Chap. II. Distribution of the Ores of Copper.
Chap. III. Sampling and Assaying of Copper.
Chap. IV. Chemistry of the Calcining Process.
Chap. V. Preparation of Ores for Roasting.
Chap. VI. The Roasting of Ores in Lump Form.
Chap. VII. The Roasting of Ores in Pulverized Condition.
Chap. VIII. Automatic Reverberatory Calciners.
Chap. IX. The Smelting of Copper.
Chap. X. The Chemistry of the Blast Furnace.
Chap. XI. Blast-Furnace Smelting.
Chap. XII. Blast Furnace Construction.
Chap. XIII. General Remarks on Blast-Furnace Smelting.
Chaps. XIV and XV. Pyritic Smelting.
Chap. XVI. Reverberatory Furnaces.
Chap. XVII. The Bessemerizing of Copper Mattes.
Chap. XVIII. The Electrolytic Refining of Copper.
Chap. XIX. Selection of Process and Arrangement of Plant.

In the chapters devoted to the discussion of chemical principles underlying the science of copper metallurgy the author presents in a clear manner the requirements for successful metallurgical practice. With reference to the former editions there has naturally been but little change of text. It is in the chapters devoted to furnace construction and working that the revision and rearrangement is most marked. Among the modern furnaces described are "The Allen-O'Harra Calciner," the Pearce Turret Calciner, the Improved Fire Hearth Spence Furnace with an upper drying hearth, known as the Kellar-Gaylor-Cole Calciner, the Brown Horseshoe Calciner, the Spence Automatic Desulphurizer. Detailed ore hearths for the Fusion Furnaces, Reverberatory Furnaces and the Stalman, Parrot, Anaconda and Leghorn Converters for Bessemerizing copper matte.

In these descriptions the value of the author's careful work and able

compilation is very evident. Much that is of importance to the furnace worker, as well as the student, is given in satisfactory detail and the clear inset illustrations greatly assist in easy comprehension of the descriptions.

The work is a standard of its kind and should appeal strongly to all interested in the smelting and refining of copper, whether metallurgist, chemist or student.

It is to be regretted that the discussion of foreign practice is not more extensive, so that the work would be a standard in other countries as well as in this. The paper, typography, binding and illustration are of excellent quality. There are 642 pages, with 84 illustrations, many of which are large insets from working drawings of the furnaces. J. S.

The Lixiviation of Silver Ores with Hyposulphite Solutions, with special reference to the Russell Process. By CARL A. STETEFELDT. 2d edition. Published and sold in the United States and Mexico by the author. Address, 967 Alice St., Oakland, Cal. For all other countries the sale is conducted by Craz and Gerlach (Joh. Stettner) Freiberg in Sachsen, Germany. Price, $5.00.

The first edition of this work was given to the public in 1888 and was received with great attention by all directly or indirectly interested in the subject of treating silver ores by wet methods.

The treatise was mainly composed of the author's papers on the subject, suitably modified and revised, which originally appeared in the Transactions of the American Institute of Mining Engineers. In the second edition much has been done to improve the work. In addition to the revision and rearrangement the author has introduced considerable new matter obtained from laboratory and professional practice to the extent of replacing nearly a hundred pages of the original work.

The introduction gives a brief review of the subject of lixiviation, with special reference to the advantages claimed for the Russell process, discusses the ores available for treatment, etc. Part I. is devoted to the chemistry of the lixiviation process and is ably handled by the author, whose clearness of discussion and lucidity of style deserve the gratitude of the profession. This part is systematically arranged as follows:

Chapter I. is devoted to the "chemicals" and gives in detail the various compounds used, their solubilities, stability, preparation, cost, etc.

Chapter II. deals with the chemical reactions involved. The compounds of silver, lead, gold and copper are discussed, giving their properties, manner of dissolving, effect on solutions, etc. Many interesting facts are here presented and the author's able treatment of the subject renders this part of the work of great value not only to the practical man but to the student.

Chapter III. takes up the "Extra Solution" and its reactions with the various compounds involved, also an able discussion on the effect of atmospheric influences.

Considerable statistical matter giving the results of professional experiments are pleasingly arranged in tabular form and comprise one of the more important features of the work.

Chapter IV. contains a few words on the extraction of gold by the amalgamation and lixiviation processes, giving the practice as carried out at the Marsac and Bertrand Mills. The results of the practice as there adopted showed a decided advantage in favor of the Russell process.

Chapter V. discusses the chemistry of the wash water, dividing the salts into those easily soluble in water; those not easily soluble in water; those not easily soluble in water, but soluble in brine; those practically insoluble in water, but soluble in brine, and those insoluble in water, but soluble in wash water brine.

Chapter VI. describes the precipitation from hyposulphite solutions, finishing with a description of laboratory work giving the lixiviation tests with the "Extra" solution.

One hundred and three pages are devoted to this first part.

Part II. deals with the practical execution of the lixiviation process and the arrangement is as follows:

Chapter XI. gives details of tanks, presses and pumps, stating construction and costs.

Chapter XII. discusses the solutions, manner of preparing, etc.

Chapter XIII. deals with method of handling the solutions.

Chapter XIV. is devoted to the treatment of raw and roasted ores, the silver-bearing wash water and the lixiviation.

Chapter XV. discusses "trough" lixiviation.

Chapter XVI. describes the precipitation of the metals from the lixiviation solution, giving the mill practice.

Chapter XVII. is devoted to the refining of sulphides and deals with the older practice and the modern humid methods.

Chapter XVIII. is a comparison of the Russell practice with the ordinary, as carried out at Cusihuiriachic, Chihuahua; Sierra Grande, N. M.; Yedras, Mex., and at the Blue Bird, Marsac and Ontario mills.

Chapter XIX. gives the practice at Aspen, Col., Marsac Mill, Park City, Utah, and Mt. Cary, Nev.

For a general view of the arrangement of facts and clearness of discussion the author deserves the thanks of the chemist and the metallurgist, whether they are workers in the field or engaged in the theoretical study of the subject.

The work covers 204 pages, printed on good quality paper, with clear typography and fittingly bound in brown board covers. The illustrations are limited to two full inset plates, one showing a modern sulphide drier, and the other giving the plan and elevation of a modern lixiviation plant.

J. S.

Alternating Electric Currents. By EDWIN J. HOUSTON, PH. D. and A. E. KENNELLY, SC. D. Published by the W. J. Johnston Company, New York. 225 pp.

In this volume, which is the first of a series of ten on electro-technical subjects of general interest, the authors put before the reader the theory and practice of Alternating Currents in a very able manner and in as simple a form as the subject allows while avoiding entirely the use of mathematics.

In the first and introductory chapter the flow of electricity in an alternating current is successfully compared to the flow of water in a river near its mouth under tidal influences. This analogy in the rest of the chapter is kept up so as to explain the ordinary technical terms. One paragraph, though, is not particularly clear. To speak of frequency of alternations and frequency of cycles is, to say the least, misleading. The frequency proper is the number of cycles per second.

Chapter II. treats of alternating electromotive forces and currents, and

includes very clear and simple explanations of self-induction and reactance. To call electromotive force "a particular variety of force," however, is wrong. The term electromotive force is unfortunately a misnomer, and attention should be drawn to the fact that electromotive force is properly not "force" at all. As practical applications of reactance, the theatre dimmer and choke coil are selected and their advantages dwelt upon. The chapter closes with a few remarks on the physiological effect of the alternating current.

Next the different types of uniphase alternators are considered. They are described in detail, and their methods of excitation explained at length. The subject of the determination of "power," both mechanical and electrical, is then taken up. Examples of the power taken or produced by commercial apparatus are given, beginning with the simpler cases and finally ending with that of an alternating current circuit. Here the paragraphs relating to the "power factor" leave the subject as if this "power factor," instead of being a perfectly definite and determinable quantity for each particular circuit, were a matter of mere guess-work. Although the difficulties of treating the subject without the aid of mathematics are fully realized, yet it seems as if it were capable of clearer presentation.

The principles of the transformer are very well shown by forming an analogy between it and a pump having high and low pressure cylinders. The action of this important piece of apparatus is beautifully explained from the "choking" effect. The functions of the step-up and step-down transformer are dwelt upon.

The remaining chapters of the book are taken up with incandescent lamps, direct and alternating motors, a simple and clear presentation of multiphase currents including descriptions of multiphase generators and finally multiphase motors.

The book as a whole is a valuable contribution to electrical literature as an elementary treatise and is full of information presented so as to be especially fitted for the non-technical reader. W. H. FREEDMAN.

BULLETIN OF ALUMNI AND COLLEGE NEWS.

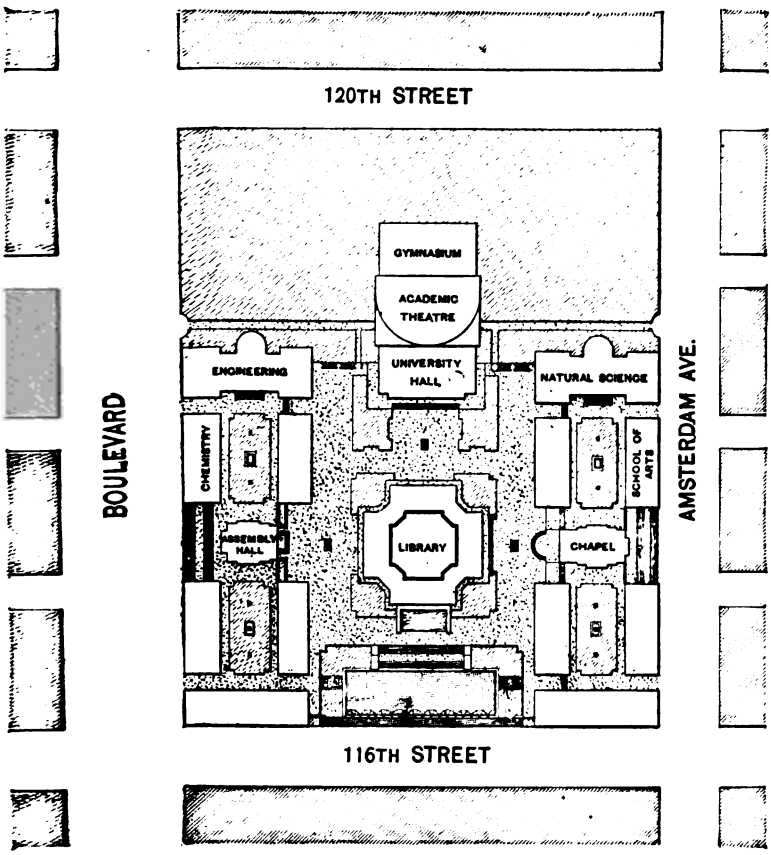
The following circulars have been sent with additional illustrations to all graduates of the SCHOOL OF MINES. The committee met again in October, 1895, and an account of their further efforts will be given in the next QUARTERLY:

MORNINGSIDE HEIGHTS.

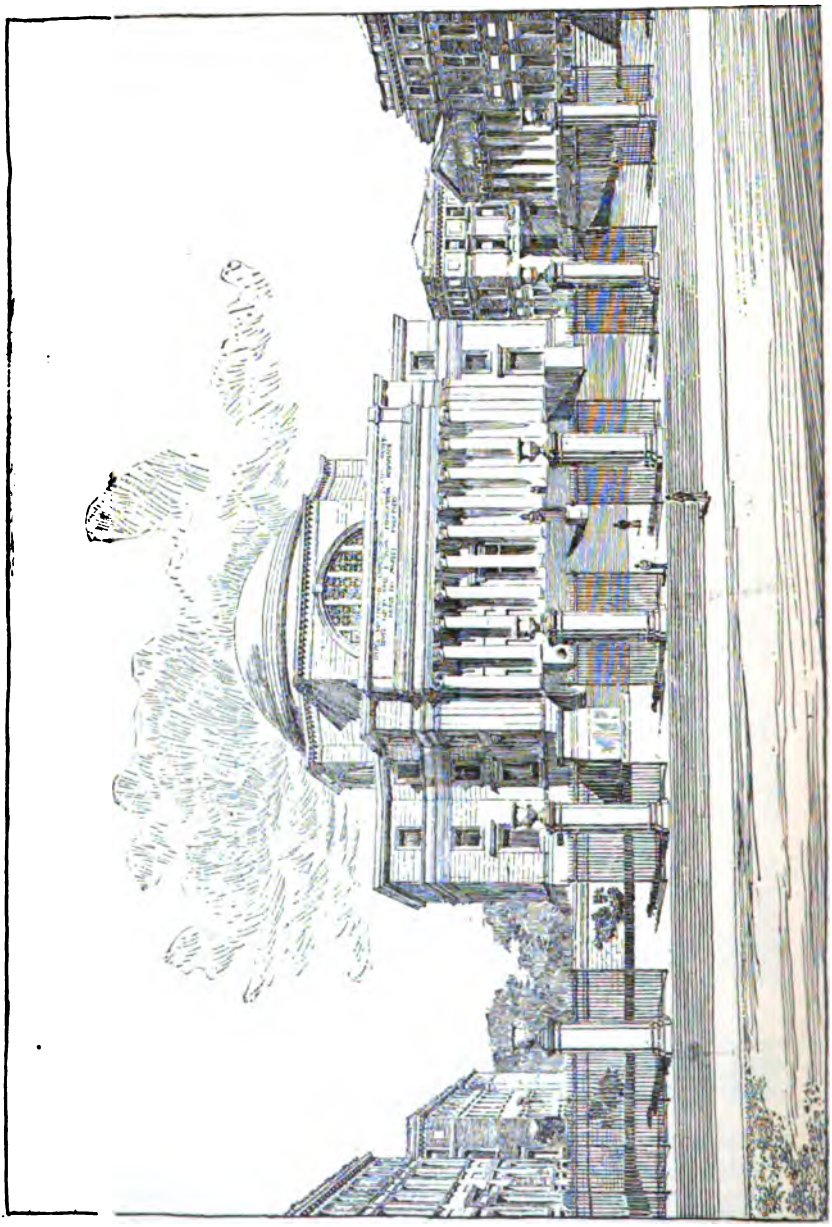
The new site recently bought by Columbia College, with its immediate surroundings, is shown on the accompanying map.

The purchase of this property marks a new and important era in the history of Columbia College—an era, it is hoped, of unrestricted growth

and development. The new location is large enough for all future needs, and will be the permanent home of the University. At the same time it is in the heart of the city, so that the metropolitan character of the institution is not sacrificed. A university can attain its full development only in a great city, with its treasures of art, literature and science, its galleries, libraries and museums, its hospitals, its law courts, its great engineering works, its countless industries and its social and economic problems. In a metropolis each student is surrounded by object-lessons in his own specialty, and has every advantage and incentive for thorough and earnest work. Life in a great city is an education in itself.



The location of the property is ideal in every respect. It lies on a bold ridge overlooking the Hudson and high above the general level of the city. Close at hand are Riverside Park on the one side and Morningside Park on the other, while Central Park lies at the foot of the hill to the south. The College is thus removed from the turmoil of city life and traffic, only little of which will climb these heights or cross this belt of parks. The famous Riverside Drive, the Boulevard, a shaded path-



way 150 feet wide, Amsterdam and Morningside Avenues, each 100 feet wide, traverse the ridge from north to south and furnish dignified approaches to the College from all directions.

The great advantages of a location in this part of the city have been recognized by other institutions. In the immediate vicinity are the sites for the Cathedral of St. John the Divine, St. Luke's Hospital, the Teachers' College, Barnard College, and the monumental tomb of General Grant.

The College property extends from 116th Street to 120th Street, four blocks, and covers about seventeen acres—a large piece of ground to be taken in a great city, but none too large for the future requirements of the University. It is about nine times as large as the present College block between 49th and 50th Streets, and twice the size of Madison Square. It lies on the very summit of this ridge, is surrounded by broad streets and avenues on all four sides, none less than 100 feet in width, while the ground itself lies above the level of the street and rises to a gentle eminence in the centre. All this makes possible a most effective placing of the buildings, the architectural details of which will be seen to much better advantage than ordinarily is possible in a large city.

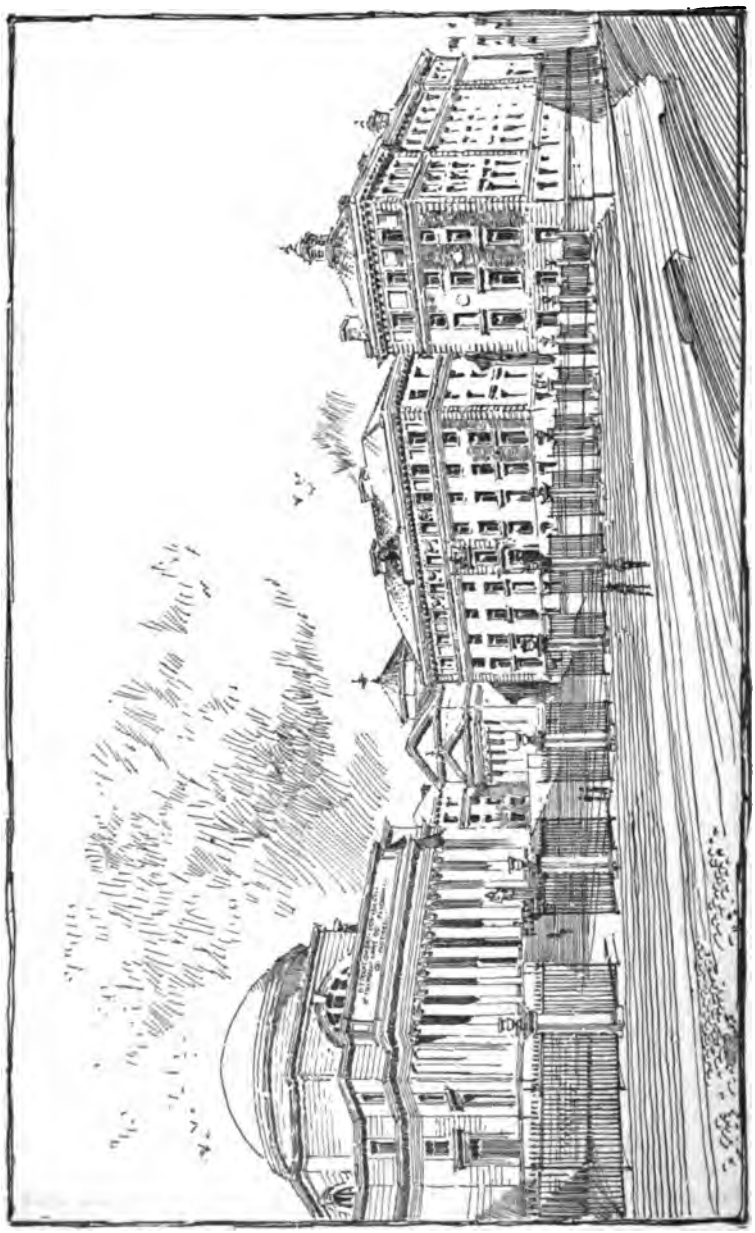
The plans for the development of this noble site have been the subject of long and careful study by the College authorities, assisted by a commission of eminent architects. The accompanying map shows the arrangement of buildings as finally adopted. The northern part of the property, on which there is a fine grove of large trees, will be reserved for the future growth of the University. On the remaining two-thirds of the tract are to be grouped eighteen buildings which will probably answer all requirements for a generation to come. In the arrangement of these buildings the ruling idea has been to economize space without sacrificing light and air, and to leave the unoccupied ground in such shape that it can be used to the best advantage in the future.

Nearly all the eighteen buildings outlined could be utilized immediately; while all of them and more will be required in the near future. It is not expected, however, that the large sum of money necessary for this purpose will be secured for some years to come. At first, therefore, the efforts of the College authorities, the alumni and friends of Columbia will be directed toward securing the money for such of the buildings as are necessary for the temporary accomodation of the departments, to make the removal to the new site possible, leaving the others to be built as the necessary funds are secured. It is not intended that any part of the present endowment of the College shall be used for buildings. The income is barely sufficient for present needs, and the endowment will have to be increased, not diminished, if the growth and natural development of the College is to continue and is not to suffer a check.

It is proposed by the College authorities to move to the new site in October, 1897. The buildings which must be erected at once, if the removal on that date is to be practicable, are the library and the buildings for chemistry, engineering, natural science, and the school of arts.

The accompanying views will convey an idea of the general style of the buildings. The library is from the accepted plans,* the other build-

*By McKim, Mead & White.



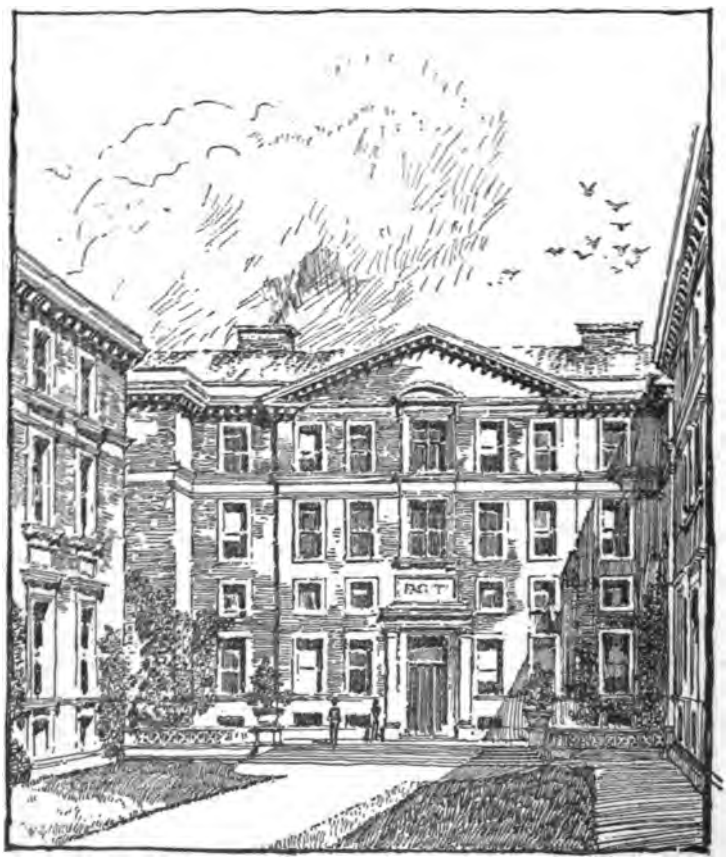
ings are from preliminary studies. The style is classic and renaissance, and each building will have a certain degree of individuality, though harmonizing in style and in general proportions with the surrounding buildings. The library is to be of Indiana limestone. The other buildings will be of the same stone, or of brick in combination with limestone.

The library building will be necessarily the first to be erected. It will have capacity for 1,500,000 books, being second in size to the Congressional library at Washington, and would contain two collections of books the size of the celebrated Bodleian library at Oxford. Until all the space is needed for books the library building will accommodate the schools of law, political science and philosophy.

North of the library is a group of three buildings under one roof, University Hall, with the academic theatre and gymnasium in the rear, the great dining hall above and the engine and boiler plant below. To the east and west of the library building are the chapel and the assembly hall.

The College and its associated schools should have an academic theatre, in which commencement exercises and other public functions may be held, and should not be dependent on a hired hall for such purpose. The students need the chapel, the assembly hall, the gymnasium, the dining hall and dormitories for the cultivation and advancement of their moral, social and physical well-being. The committee is inclined to lay great stress on all of these, and especially on the desirability of suitable dormitory buildings. These are important, not only to provide students from a distance with comfortable and sanitary lodgings near the college at reasonable cost, but also to serve as a nucleus for that college life which tends to develop the college spirit and devotion to *alma mater* which adds so much to the power and influence of any institution. The

question of the erection of dormitories on the College site itself is still an open one, the trustees having postponed final action in the matter until the necessity for a decision shall arise. In the opinion of your committee, dormitories, either on the College site or on adjoining property, in addition to their other advantages, might be made an important source of revenue to the College, and might be given as an endowment of some department of instruction.



The following buildings are thus considered most important for the full and proper development of the University and to secure for the students all possible benefits of their college life. The cost in each case is approximate:

Dormitories (four),	$800,000
University Hall,	250,000
Gymnasium,	200,000
Academic Theatre,	250,000
Chapel,	200,000
Assembly Hall,	250,000

While the above are most desirable and important, the trustees have decided that the following buildings are absolutely necessary, and must be built before the College can remove to its new site. These must therefore have the precedence:

*Library,	$1,000,000
Engineering,	300,000
*Natural Science,	300,000
Chemistry,	200,000
School of Arts,	200,000

So far as the School of Mines is concerned these will furnish only temporary and quite inadequate accommodations, especially for the departments requiring laboratories.

The Natural Science Building will contain the departments of mineralogy, geology, palæontology, experimental psychology, botany and biology, with the museums, laboratories, lecture and conference rooms.

The Engineering Building will contain temporarily the departments of mining, mechanical, electrical and civil engineering and architecture. This assignment is considered as a temporary one only, as the whole building is none too large for mechanical engineering alone. Eventually, at least three buildings will be needed to accommodate the above departments. Adjoining this is the Chemical Building, to contain the departments of chemistry and metallurgy and the necessary laboratories, museum and lecture rooms. This also is looked upon as a temporary arrangement, as the whole of this building and a second one of equal size will be required in the future for chemistry alone. The building corresponding to this on Amsterdam Avenve will contain temporarily the department of physics, mechanics, mathematics and such departments of the School of Arts as are not otherwise provided for. It is intended, however, to erect a special building for physics as soon as the necessary funds can be secured.

For the last thirteen years the School of Mines has been very seriously crippled and its growth checked by inadequate buildings. During the same period other prominent schools have doubled, trebled and quadrupled their accommodations. In its earlier years the School of Mines had in many respects the finest laboratories in the country. The abundant room at the new site will again enable us to take the lead in this direction. It is important to provide, above all, suitable laboratories and shops for instruction in mechanical engineering. The demand for mechanical engineers is far greater at present than for mining or civil engineers, and this demand is increasing rapidly. Not only this, but better facilities for instruction in mechanical engineering are most desirable to strengthen the courses in mining, civil and electrical engineering, and to make possible the establishment of courses in chemical engineering, and in marine engineering. Your committee has reason to believe that the introduction of a course in mechanical engineering, with proper laboratories and shops, would greatly increase the number of students and add to the prestige of the School of Mines. The Greater New York is the largest manufacturing centre in the country, and Columbia should not

*Since the first edition of this pamphlet was printed it has been announced that these two buildings will be given by President Low and Mr. W. C. Schermerhorn. The generosity of these gentlemen enables the School of Mines Alumni to concentrate their efforts on the Engineering and Chemistry Buildings.

neglect the education of those who will take charge of these great industries.

A building is required for industrial chemistry to prepare men for work in many lines of manufacturing industry—for example, the manufacture of paints, dye-stuffs, cements, fertilizers, explosives and other chemical products, and such industries as gas-making, brewing, sugar-refining, tanning, bleaching, dyeing and calico-printing.

A building for mining and metallurgy, with laboratories and museums, is also necessary if the School of Mines is to retain its position in the special field which it has made its own. A building for architecture and one for physics will also be needed in the near future.

The following buildings are therefore required in addition to those enumerated as the minimum by the trustees. The erection and equipment of these buildings will put the School of Mines at once in its proper place as the foremost technical school of the world—worthy of the great city in which it is located:

Mechanical Engineering,	$300,000
Mining and Metallurgy,	200,000
Architecture,	250,000
Industrial Chemistry,	200,000
Physics,	200,000

The above figures represent approximately the cost of the buildings only, and additional money will be required for equipment and endowment, the amount varying in each case from fifty thousand dollars upward:

Respectfully submitted,

THE COMMITTEE.

Committee.—John A. Church, '67; Albert W. Hale, '67; F. Augustus Schermerhorn, '68; William Pistor, '68; Lenox Smith, '68; William Allen Smith, '68; William A. Hooker, '69; Henry S. Munroe, '69; John C. F. Randolph, '69; Elwyn Waller, '70; S. A. Goldschmidt, '71; P. de P. Ricketts, '71; Peter Townsend Austen, '72; John T. Williams, '73; Albert R. Ledoux, '74; Eben E. Olcott, '74; John K. Rees, '75; Charles M. Rolker, '75; Frederick R. Hutton, '76; Willard P. Butler, '78; Frank Lyman, '78; I. B. Johnson, '79; George C. Stone, '79; Alfred L. Beebe, '80; H. H. Hendricks, '80; Wheaton B. Kunhardt, '81; Joseph Walker, Jr., '80; M. J. O'Connor, '81; Lucius Pitkin, '81; A. H. Van Sinderen, '81; Francis B. Crocker, '82; Alfred J. Moses, '82; Wm. Barclay Parsons, '82; Edward L. Young, '82; John H. Banks, '83; Robert Peele, '83; Wm. Fellowes Morgan, '84; Frank Dempster Sherman, '84; James F. Kemp, '84; Daniel E. Moran, '84; Leon Marié, '85; Henry B. Shope, '85; Russell W. Hildreth, '85; John H. Janeway, '86; Henry Hobart Porter, Jr., '86; Charles H. Davis, '87; Lea McI. Luquer, '87; William J. Schieffelin, '87; Henry Parsons, '88; A. A. Stoughton, '88; Joseph B. Taylor, '88; D. Le Roy Dresser, '89; Andrew E. Foyé, '90; J. Monroe Hewlett, '90; Frank W. Kinsey, '91; Gustav R. Tuska, '91; Edward B. Durham, '92; Eugene Merz, '92; Robert D. White, '92; George H. Clark, '93; L. E. Gregory, '93; H. K. Masters, '94; Edwin H. Messiter, '94; Howard S. Hadden, '95; Z. H. Jarman, '95; Charles D. Shrady, '95; Frederick R. Hutton, *Secretary*; Henry S. Munroe, *Chairman.*

CIRCULAR LETTER TO THE ALUMNI OF THE SCHOOL OF MINES.

Columbia College has purchased a noble site for its permanent home, to which it is proposed to move in 1897. The cost of the new site and of the buildings for immediate use, with the expenses of removal, will require a total expenditure of about five and a half million dollars. Including the generous gifts of President Low, Mr. W. C. Schermerhorn and other members of the board of trustees, about four million dollars have been provided, leaving a million and a half to be secured. This money must be raised through the efforts of the College authorities and by the alumni and friends of Columbia.

Large as is the endowment of Columbia, no part of it is available nor can be spared for the erection of buildings at the new site. The income from all sources is barely sufficient for the present needs of the University, and the endowment must be increased, not diminished, if this institution is to keep pace with the times. A large share of the buildings are for the use of the School of Mines, and the school will be the chief sufferer if a sufficient number of buildings cannot be secured. A large responsibility rests upon the School of Mines alumni, and it is important that each and every one shall accept his share of this burden. It needs no argument on the part of your committee to urge this duty upon you. Columbia College has expended from its income and other funds over $4,200,000 on the School of Mines in the last 30 years, and has received from students during the same period about $1,000,000.

The Alumni thus owe to Columbia more than enough to erect all the buildingr needed at present for the school. The graduates, however, are mostly professional men, earning moderate salaries, so that it is not probable that they can themselves contribute the large sums necessary.

Each alumnus has wealthy relatives, friends or clients. If the useful work of the School of Mines, and its present need, were properly set before such persons it is quite certain that several of the buildings would be provided in a very short time.

To a public spirited and generous man no better or more useful disposition of his money can be suggested than the education of young men who are to develop our mineral resources, or construct and take charge of our public works, railroads, canals, harbors and waterworks, our shops, mills and factories, and the many branches of modern industry. The useful work accomplished by a trained body of engineers, chemists, architects and scientific men is beyond computation. The saving of wealth by their combined efforts is enormous. The money expended in the education of such men is returned to the country a thousand fold.

Any money given to Columbia is sure to bring forth the best results possible. There are many institutions in the country with fine buildings, well equipped for the purposes of instruction, which yet languish because they are insufficiently endowed. It is generally much easier to obtain money for buildings than for endowment. The professors of such institutions are necessarily few and ill paid. Men competent to instruct in applied science can earn much more by practicing their professions than most colleges can afford to pay them. If able men accept these positions they do so at no small sacrifice, and they are likely to be called upon to do the work of three or four. Columbia is fairly well endowed, has a

large faculty, and can pay salaries large enough to secure such men as she needs for her work.

One or two million dollars added to the large endowment of Columbia will produce better results than the same amount expended in establishing a fourth-rate institution elsewhere.

Should additional argument be necessary it may be urged that a building given to Columbia will be an enduring monument to the giver or to the memory of a beloved son, a father or husband. No more magnificent monument can be suggested than one of the beautiful group of buildings with which it is proposed to crown our modern Acropolis. No more enduring monument can be imagined than a hall devoted to the education of young men, which will be cherished and guarded by an ever increasing body of grateful and devoted alumni.

President Low, in his annual report to the Trustees, says: "By general consent the new site is unsurpassed in location by that of any university in the world. It is near the Grant monument and the new Cathedral of St. John the Divine. Any one placing a building upon this site, in such a location, may be confident of a memorial at once enduring and useful, and one which will be before the eyes of the people of the United States almost more than any college building in the land. Every stranger that visits New York will certainly visit these heights to see the monumental buildings which will be clustered there; and the people of New York, in showing them to their friends, will become familiar with them, and their affection will dwell upon them as among the most important buildings that minister to their civic pride."

HENRY S. MUNROE, *Chairman*,
FREDERICK R. HUTTON,
WHEATON B. KUNHARDT,
Executive Committee.

DEPARTMENT OF METALLURGY.

The following materials have been received as additions to the Metallurgical Collections of the SCHOOL OF MINES since the last issue:

American magnesite bricks, manufactured by the Fayette Manufacturing Company, of Pittsburgh, and silica bricks from the same company, illustrating their method of manufacture.

A shell of pig-iron from Connellsville, Conn.

Gold amalgam produced by electrical deposition, from Tombstone, Arizona.

A series of fine castings of link chains, made by Piat & Co., of Paris, and a collection of the late Mr. M. H. Tresca, of Paris, illustrating the law of the flow of metals, presented to the School by his sons. These specimens consist of a series illustrating the flow of lead through concentric and eccentric orifices; the flow of metals in the stamping of medals in different metals, the thickness of the medal being made up of several sheets, so that the flow is shown from the top and the bottom; etched surfaces of drop forgings, illustrating the flow there and specimens of rolled metal, showing that the increase is in the direction in which it is rolled and not sensibly in the width.

This collection of Mr. Tresca's is one of the most valuable additions to the metallurgical cabinet that has been made for some time and the School is to be congratulated on receiving it.

By decree of the President of the French Republic, dated the 16th of July, 1895, Dr. Egleston, of the SCHOOL OF MINES, in consideration of his services rendered to France and to science, was promoted to the position of Officer of the Legion of Honor of France. This promotion was accompanied by a diploma, the beautiful insignia of the Order and a very complimentary letter from the Consul-General of France. The promotion is a great honor both to Dr. Egleston and the institution which he has so long served.

DEPARTMENT OF MINING.

This year, for the first time, the summer school of mining was held as far west as Colorado. The 13 students forming the class went out in a body, and on June 3d, at Central City, met Prof. Peele, who had gone ten days in advance to make the necessary arrangements.

Central City, and its near neighbor, Black Hawk, lie in a narrow gulch at an elevation of 8000 to 8500 feet above sea-level, well up on the eastern slope of the main range of the Rocky mountains, and situated about 40 miles northwest of Denver. These towns, among the oldest in Colorado, comprise the business centre of the Gilpin county mining district. At Black Hawk was built in the early days the original establishment of the Boston and Colorado reduction works, which now occupy a more spacious site at Argo, on the outskirts of Denver. The old town —old according to Western ideas—contains the gold mills which treat the bulk of the ores produced in the district. There are at present in operation twelve or thirteen mills, with an aggregate of about 575 stamps. Nearly all the mines of the district lie within an area of only a few square miles, and evidence of the very large amount of work which has been done is found in the numerous "waste dumps" which mark the mountain slopes on all sides. Here are to be found the comparatively small scale, economical methods of mining characteristic of many of the camps of the gold and silver regions of the West. Those of the class who had attended the summer school of 1894, which was held in the large Lake Superior copper mines, were able to make interesting and useful comparisons of methods and results. If these observations were not always favorable to the Colorado mines, the lessons to be learned were not the less valuable.

The mines at which most of the regular class work was carried on were the Gunnel, the Saratoga and the Gregory-Bobtail. Of these, one is opened by long tunnels, the others by inclined and vertical shafts.

The veins of the district are fissures, having invariably a steep dip, and over-hand stopping is everywhere employed. Low grade ores are the rule; partly free-milling, but containing a large percentage of gold-bearing copper and iron pyrites.

Several days were devoted to a careful study of the systems of milling in two or three of the mills. Toward the end of the session, visits were made to other mines in the neighborhood, and to the Newhouse Tunnel, which is being driven in at a low level from Idaho Springs, to tap the Central City veins at a depth of from 1,000 to 1,200 feet below the surface. This tunnel, when completed, will have a length of nearly three miles. Then a two days' trip was made to Georgetown and Silver Plume, where, at the latter place, the Pelican-Dives mine was visited.

Finally, the class went to Denver, where a couple of days were spent at the Boston and Colorado, and the Omaha and Grant smelters. This ended the session of the Mining School.

On July 8th the students met Prof. Kemp at Golden, and devoted a week to field geology.

The members of the Summer School were everywhere received with the greatest kindness, and all enjoyed and profited by their Western experience.

It is pleasant to acknowledge here the courtesy and assistance extended by Mr. Benjamin B. Lawrence, manager of the Pelican-Dives mine; Messrs. John Best and Ernest Le Neve Foster, of the Saratoga; Messrs. Kimber and Fullerton, of the Gunnel mine, and many others, who showed themselves the friends and well-wishers of the School of Mines. While in Denver, the entire class was most hospitably entertained, on the evening of the Fourth of July, by Mr. and Mrs. B. B. Lawrence.

DEPARTMENT OF GEOLOGY.

The past summer has been a busy one in the geological department, as it is the season that is most favorable for field work and that allows time for its pursuit. After commencement Prof. Kemp spent a week in further study of the granite areas on the north shore of the Sound. On July first he left for Colorado, and July fifth joined the students of the Summer School of Mining, in Denver. The following day headquarters were established at Golden, and during the following week daily excursions were made across the upturned Mesozoic strata that stand on edge against the granite. Rocks were gathered, dips and strikes noted, and many fossil plants were secured from the fire-clay excavations in the Dakota and Laramie formations. One trip was made to the coal mines at Ralston Creek, where the strata are vertical, and another to Morrison, where the upturned sandstones are scarcely inferior to those of the Garden of the Gods. The museum is the richer by five large boxes of specimens, mostly fossil plants from the Dakota, Laramie and Denver beds, the last named on Table Mt. The success of the trip was in no small degree owing to the kind interest manifested in us by Captain E. L. Berthoud, of Golden, to whom all the party are glad to express their warmest thanks. The class also visited the State School of Mines at Golden, and were greatly interested in its fine equipment. July 15th the party broke up, and Prof. Kemp went with Messrs. Holden, Of and Witherell to Cripple Creek, where a week was all too quickly spent in trips about this vigorous and remarkably prosperous camp, with its rare types of ores and rocks. A week of collecting in the park region south of Florissant and at the fossil plant beds of this place, terminated the Western journey. On the return Prof. Kemp visited the zinc and lead district of southwest Virginia, obtaining a fine suite of specimens, and passed a week with J. E. Jones, '95, in the Pocahontas coal field of West Virginia, by which visit some important additions were made to our collections. During September Prof. Kemp continued field work in the Adirondacks under the direction of the State Geologist, Prof. James Hall, and practically completed the reconnoissance of Essex county, that has now been in progress several years.

Mr. Hollick planned to spend about two weeks on Nantucket and the

same length of time on Long Island, in the study of surface geology and in the collection of fossils. The plans were interferred with, however, by the printing of Dr. Newberry's posthumous "Flora of the Amboy Clays" and the consequent necessity of careful proof reading by Mr. Hollick, in connection with the College library facilities. Galley and page proofs were read and the work may be expected to appear shortly. Only one week was spent at Nantucket, but a good collection of Tertiary molluscs was made, at the classic locality of Sankaty Head, which have been deposited in the Geological Museum.

A short visit was subsequently made to Center Island in Oyster Bay, and some fine specimens of Cretaceous leaves were collected, which have been added to those already in the museum.

During the month from June 10th to July 11th, Messrs. Gilbert van Ingen and Theodore G. White were engaged in studying the Cambrian and Ordovician faunas of the Champlain Valley, the expenses being partially defrayed by the appropriation for the Summer School of Geology. Mr. van Ingen's work was largely upon the lower members, viz.: the Calciferous and Chazy. Mr. White paid particular attention to the upper members of the Ordovician (Black River, Trenton and Utica), and was successful in obtaining a large amount of fine material which will be of value in the preparation of his doctorate thesis on the Trenton Faunas of the Champlain Valley.

During the trip all the principal localities of the upper Ordovician and many of the lower were visited, the sections carefully measured and large collections of fossils made from all horizons. The total weight of the collections sent in amounts to 4,500 pounds, a considerable increase to the Museum of Geology.

Among the more interesting results of the trip the following may be noted

1. The discovery of a zone with large *Maclureas* at the top of the Black River limestone in the vicinity of Chazy, Clinton county, N. Y.

2. The discovery of abundant foraminiferal remains of the genus *Rotalia?* (Parker and Jones) in the Calciferous limestone south of Plattsburgh, N. Y.

3. The discovery of limestone layers containing abundant trilobite remains beneath the famous "Fort Cassin," and above the *Caula* bed at Fort Cassin, Vermont.

Mr. White has also made a supplementary trip to Trenton Falls, N. Y , to study the type region of the Trenton.

The department has recently prepared a glass model of the large magnetite ore bodies of Mineville, N. Y. Sections to the number of twenty-three, taken each 100 feet across the ore have been transferred to parallel glass panes about 24″ x 34″, thus affording a view of the ore body in three dimensions.

Department of Civil Engineering.

The course in civil engineering will be considerably strengthened this year by material accessions to first and second year subjects as well as by developments in the third and fourth years, in consequence of which more design work in fourth year subjects can be accomplished, while the time devoted to thesis work will be more largely extended. The subject of

botany has been introduced in the first year, and it is designed to afford a course of study with a basis of a general character, but with those special developments which are of value to the civil engineer. The subjects of projective drawing and descriptive geometry have been extended in the first and second years, while that of stereotomy or stone cutting has been introduced in the second year. These latter changes have added materially to the efficiency of the branches of work to which they belong.

The extension of time devoted to thesis work will, it is believed, contribute effectually to greater excellence in the graduation papers than has hitherto been reached. The promise of these results is already made in the advanced character of the thesis work now in progress.

The subject of Roads and Pavements of the second year has been transferred to Mr. Tuska, Mr. Foyé having assumed some extra duties in the course on the Resistance of Materials. A working collection of materials, tools and machines characteristic of all grades of road or street work is now being made for use in connection with this subject.

The session of the Summer School in Surveying at Morris, Conn., was one of marked success. A greater amount of work than usual was accomplished, both in the field and office, with a degree of excellence which compares favorably with that attained in the past. A hydrographic survey was reëstablished for the division of civil engineers and the average length of the railroad surveys reached four miles. The field and office operations connected with the latter were conducted to the point of complete preparation of the various lines for traffic. At one time over seventy students were in attendance, which is the largest number ever accommodated at the camp at one time.

ELECTRICAL ENGINEERING DEPARTMENT.

The theses of the last graduating class were of special interest and value. The work of Messrs. Ormsbee and Benedikt was embodied in a paper on "Electric Power in Factories," which was presented by Professor Crocker at the annual meeting of the American Institute of Electrical Engineers at Niagara, June, 1895. The use of electric motors in factories is spreading rapidly, many large iron works, cotton mills and other establishments having already adopted them; hence the definite information which this paper contained was highly appreciated and has been reprinted in many electrical and mechanical journals at home and abroad.

The thesis on "The Relations between Pressure, Electrical Resistance and Friction in Brush Contact" of dynamos and motors, by Messrs. Cox and Buck, was published in *The Electrical Engineer* of August 7, 1895. This paper contains the only exact data now available on this subject upon which the satisfactory working of direct current machinery is so dependent. A thesis on "The Effects of Temperature upon Cotton and Silk Insulation," by F. C. Reeve, published in *Electric Power*, June, 1895, gives carefully obtained results on this matter, which are also of great practical importance in connection with electrical apparatus. A thesis on "The Electro-deposition of Alloys," by F. Sutton, which appeared in *Electric Power*, August, 1895, possessed considerable scientific as well as technical interest. This paper not only gave the conditions under which brass may be successfully electro-deposited, but also showed how the proportion of zinc to copper may be varied from 0:100 to 50:50

as may be desired by merely regulating the voltage applied. This article, which is very suggestive of the possibilities of electro-metallurgy, was reprinted in full in the *London Electrical Review*.

DEPARTMENT OF MECHANICAL ENGINEERING.

The work of the department in class-room routine has been but slightly modified and improved over last year. In the experimental side an addition has been made to the equipment by the purchase of a 10-horse power De La Val steam turbine, which will be mounted and connected for experimental investigations upon power, steam consumption, etc. The work with the testing machines is also to be extended slightly in the direction of variety, and the work with the steam engine indicator is to be made more complete and accurate. Additions during the summer have been made to the outfit of injectors, extensimeters and small apparatus for general purposes. A considerable addition to the cabinets of the department has resulted from a transfer of kinematic models from the department of mechanics.

Study has been begun in marine engineering, as a post-graduate specialty in this department.

DEPARTMENT OF ASTRONOMY.

1. Prof. Jacoby has returned from his leave of absence. He brings back with him several pieces of work of considerable importance.

The Repsold Measuring Machine (the gift of Rutherfurd Stuyvesant) will be used under Mr. Jacoby's direction in measuring photographs of the polar star taken at the Royal Observatory at the Cape of Good Hope and at Helsingfors. The investigation will be used to discover the effects of optical distortion of the object glasses used in the Astrophotographic work.

The Repsold Machine will also be used in measuring some of the Rutherfurd photographs.

2. The observations for variation of latitude are going on at the observatory at 116th street in conjunction with the Royal Observatory at Naples. The campaign began in May, 1893. The observers were Profs. Ree and Jacoby and Dr. Davis down to July 1894. Since that time the observs ations have been made by Prof. Rees and Dr. Davis.

3. Dr. Davis has been appointed Tutor in Astronomy.

4. The work on the Rutherfurd measures is going on. Dr. Davis is making the necessary calculations.

5. The department of astronomy is giving instruction to 50 students: 2 in the advanced class of Practical Astronomy, 6 in the first class in the same subject, 15 in the course on Descriptive Astronomy and 37 in the courses in the School of Mines.

DEPARTMENT OF BOTANY.

Professor Britton, acting as Secretary of the Board of Managers and of the Scientific Directors of the New York Botanical Garden, has been much occupied recently in conferences with experts appointed by the Board of Commissioners of Public Parks in determining the boundaries of the garden which is to be established in Bronx Park. The Act incorporating

the New York Botanical Garden provides that, when a sum not less than $250,000 shall have been obtained by the incorporators through subscriptions, the Board of Commissioners of Public Parks shall set aside 250 acres of Bronx Park for the use of the garden, and that the city shall appropriate $500,000 for the erection and equipment of the buildings needed. This primary endowment fund of $250,000 having now been obtained, the Directors have decided to authorize a study of Bronx Park looking towards the selection of the most desirable tract for the purpose in view. The committee of the Directors charged with this study consists of Professor Britton, Chairman, Professor Kemp, and Professor W. Gilman Thompson, of the University of the City of New York.

Mr. John K. Small, having received the degree of Doctor of Philosophy, after holding a Fellowship in Botany for two years, has been appointed Curator of the Herbarium, and will also aid in two of the courses of instruction. He is at present engaged in field work in the South, continuing his studies on the Flora of the Southeastern United States in conjunction with the Geological Survey of Georgia, and in active preparation of his book on the botany of that region, designed as a companion volume to Professor Britton's Flora of the Northern States and Canada. Mr. Small's graduation dissertation, forming the first volume of *Memoirs from the Department of Botany*, "A Monograph of the North American Species of the Genus *Polygonum*," was issued in April. It is a quarto volume of 178 pages and 85 plates, illustrating all the species, natural size, and the comparative anatomy of the stems of species selected from the several sub-genera. He has begun a monographic study of the North American species of *Saxifraga*.

Dr. Albert Schneider's work on the "Lichens of Northeastern North America" is well advanced, most of the illustrations having been drawn. A large amount of valuable material has been added to the Herbarium as a result of this study. Dr. Schneider has been appointed Fellow in Botany for the coming year, and it is hoped that this dessertation may be completed for publication during next winter. He is also engaged on a translation of Westermaier's *Lehrbuch der Algemeinen Botanik*.

Dr. Carlton C. Curtis is making rapid progress in the preparation of manuscript and illustrations for his "Elementary Botany." He will devote most of the summer to this matter, and it may be possible to issue the work in time for use by the classes next October.

Recent additions to the Herbarium include collections of specimens from California, Vermont, Pennsylvania, New York, Oregon and Mexico, together with considerable miscellaneous material all obtained through exchange.

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THE

SCHOOL OF MINES QUARTERLY.

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METHODS FOR THE COLLECTION OF METALLURGIC DUST AND FUME.

BY MALVERN W. ILES.

Dust may be defined as an incoherent aggregate of fine particles of inorganic material, which have definite forms, and which, when highly magnified present angular outlines, showing them to be small pieces which have been broken off or in some manner separated from large pieces of a similar nature.

Fume also consists of fine particles of inorganic material, but it is infinitely finer than dust, and it has been produced through the agency of heat; this heat may or may not have given rise to a chemical change in the material from which it originally emanated.

We see, therefore, that it is comparatively easy to collect dust, but exceedingly difficult to collect and save fume; this difficulty is due wholly to the *size of the particles.*

The various methods for the condensation and collection of dust and fume, from metallurgical works, may be classified as follows:

A. Deposition of the fume by its own specific gravity in long flues or conduits, with or without the addition of enlarged spaces, known as settling chambers, placed either near to or at some distance from the furnace.

B. Filtering through flues, towers or chambers containing brush-

wood, coke, coarsely woven fabric or similar porous material; using water in the form of jets, sprays or intermittent streams to keep the flues from becoming choked.

C. The use of water either in the form of steam or in the shape of drops or jets projected with some considerable degree of force into or across the current of smoke.

D. Processes based upon the inverse of the preceding principle; namely, passing the smoke under and through a depth of water, either in great volumes, as in the old Stagg's Condenser, or in a more or less comminuted condition.

E. The process of passing fume through water into which is submerged a number of wire gauze diaphragms arranged one above another on horizontal planes at small distances apart.

F. The use of metal plates hung in dust chambers as at Ems, Germany.

G. The use of static electricity.

H. Filtration through cloth, or other textile fabric; which fabric is usually constructed in the form of circular bags or pipes of various lengths, ranging usually from 20 to 30 feet; hung either from the lower or upper side of the conducting pipe; or the smoke may be delivered into large chambers constructed of iron, brick, or suitable material and from the top of such chamber a series of bags may be attached vertically by the use of sheet-iron thimbles or necks.

Whilst the bags are usually made of coarsely woven muslin or flannel and are circular in form, yet it is obvious that other forms can be used.

The zinc and lead smelters usually term such places for the collection of fume, bag houses.

It would be entirely possible to add to the above list other methods which have been or are being tried with more or less success, either in the past or at present, yet it was deemed *best* not to specifically include these methods in our classification. For a part of this classification the writer is indebted to an article written by Mr. A. French, in a paper read before the British Association for the Advancement of Science. Section B, 1879.

Division A.

Many able metallurgists still think that long flues are the cheapest and most effective method that has been used. The celebrated

Dr. Percy, after having considered a very large number of methods, was inclined to this view, and so also were other metallurgists, living contemporaneously with him. The advantages and disadvantages of this method have been fully described by many writers, and are apparent to all metallurgists who have had a long experience on the subject.

Solid particles of ore blown out mechanically from a furnace, settle rapidly near the furnace, the lighter particles will be deposited farthest away. Yet there is an exception to this statement owing to the great fineness of the particles themselves. For example, a sulphide of lead may be in so fine a state of division that it will settle a much greater distance from the furnace than a large piece of silica which is specifically lighter than the sulphide of lead. On the other hand, large pieces of galena which have not been changed by the chemical action of the furnace itself, will of course settle in a dust-chamber close to the furnace.

It is entirely possible to construct chambers or flues which will successfully collect the *dust* particles, but *fume* cannot be successfully collected in this manner, although a certain small amount of fume is always found attached to the side walls, and particularly upon the lower side of the top arch of such chambers and flues. In the opinion of the writer the complete and successful fume-chamber has never been constructed, and, from the very nature of the case, never will be constructed. In a general way it may be stated that the longer the flue the greater is the saving in both flue-dust and fume. In all chambers the greater the surface exposure the greater will be the deposition of fume. Almost all flues at all metallurgical works are too small, that is to say they should be wider and higher. The velocity of the escaping gases containing metalliferous particles may be generally stated to be too great. This criticism is not upon any particular works or confined to any particular metal, place or country.

The greater the number of angles and turns through which the smoke is made to travel the greater will be the deposition of both dust and fume. In regard to this subject of angles and turns, such as hanging curtains, small bridges rising up from the bottom of the chamber, and blank walls running out from the sides of the chamber, the reader is referred to Hering's little pamphlet, published only in German. But all crooks, turns, angles, battering walls and such like primitive contrivances will invariably interfere

with the draft of the furnace, which is very apt to greatly lessen the tonnage of the furnace, and very frequently seriously interferes with its proper and normal action and may occasion a greater loss than the complete sacrifice of all fume and dust produced. This remark is particularly pertinent to roasting furnaces, where draft is induced by stacks. This subject of the variation of the direction of the smoke and the breaking up of the same by numerous angles has been carried to the greatest extent at Mechernich, Germany, and there is probably no more complicated system of dust chambers in the world than is to be found at this place. The amount of fume collected at Mechernich is comparatively large, yet the amount of fume which escapes even under such a perfect system is also very large. The writer has tested samples of fume from this place, which contained over 70 % metallic lead.

In America, dust-chambers are measured by feet, whilst in Europe they are measured in miles, and it is not uncommon to find them from one mile to five miles long and over.

Mr. W. M. Hutchings, formerly of the Dundee Lead Works, in northern Wales, stated to the writer in a letter that his dust chambers are over two miles in length. There is one place in Germany where dust chambers are three miles long. In many places in Europe, I am informed, by Dr. Thos. Egleston, that miles of dust chambers are now crumbling away and are of no use. In some places in Europe they have carried the system of dust chambers to such an extent that where they are short of room they will build dust chambers one above another, in three and four tiers. This latter practice is very bad and not to be recommended, except in the most severe emergency cases, since such chambers are difficult and expensive to construct, very difficult to brace properly, and expensive and often very dangerous to repair. Most of these chambers built in tiers are now abandoned.

Mr. E. F. Eurich, of the Chicago and Aurora Smelting and Refining Company, at Aurora, Ill., has given much thought and attention to the proper construction of dust chambers, and his work is highly meritorious. The smoke from his blast furnaces first passes through a large sheet-iron pipe, 7 feet in diameter, so arranged at the bottom that the dust is obtained in hopper-shaped receptacles with a proper slide for withdrawing the dust, after which it enters a long tortuous underground dust chamber, which is composed of heavy stone walls on the side and arched over with

brick. The smoke from all the blast-furnaces, together with the smoke from the Refining Plant, also enters this chamber. The smoke from the Roasting Plant also passes through a long tortuous chamber, which is constructed under ground and in the manner above indicated.

Mr. Eurich has tried all the various methods of brick and hanging curtains to cause the fume to go in every possible direction; the result of his tests is to run up 4-inch brick walls nearly to the center of his flues on alternate sides, causing the smoke to wind through the dust chamber in a snake-like fashion. Mr. Eurich also recommends the use of small walls to a height of about 2 feet, built up from the bottom and at right angle to the course of the flue, in order to prevent drifting of the dust after deposition.

It is believed that by the use of this method that the dust which is deposited against the face of these walls is not caught or licked up by the passing currents of smoke, as in cases where the smoke is made to go over a wall and underneath a wall. In all devices dependent upon the use of sharp angles and turns there is a marked interference witn the draft of the furnace, particularly where one has to depend upon a chimney for the draft. Most metallurgical works would be greatly improved by tearing down all the chimneys on the plant except those in connection with the boilers, and using fans. Whilst this idea of the writer is somewhat revolutionary, yet each year makes him stronger in this belief.

The Pennsylvania Lead Works depend entirely upon the length of their flues and the angles of the flues for the collection of the flue dust. Sheet-iron chambers are very largely used, recognizing fully the benefits derivable from the cooling effect on the gases.

It is well known by many that there is a much greater amount of fume and dust collected in sheet-iron pipes and flues than in brick-dust chambers. These are generally cheaper than brick-dust chambers, and where they are kept well painted they serve most excellently about metallurgical establishments, indeed there are some places where they are absolutely necessary. After having tried a very large number of paints for such sheet-iron pipes, we have adopted for all iron surfaces silico-graphite paint ground in oil and thinned down with boiled linseed oil and sufficient No. 2 dryer to cause the paint to dry readily. This paint can be obtained in barrels from the Joseph Dixon Crucible Company, of

Jersey City, N. J., and the writer believes it to be the best paint known for industrial works for either wood or iron surfaces.

The St. Louis Smelting and Refining Company were depending entirely upon long flues until the last few years before they closed down indefinitely, when a lawsuit was instituted by Messrs. Howard & Evans, brick manufacturers, who declared them a nuisance and instituted a suit to recover damages for interfering with the manufacture of their brick, claiming that the deposition of lead fume upon them injured their sale. They then adopted a water spray and tile system, which will be described under the proper heading C.

At the Pennsylvania Salt Manufacturing Company at Natrona, Pa., a series of chambers only are used, they depending upon the cooling effect of the sheet-iron and also upon directing their fume at different angles.

All the lead smelters in Utah depend, so far as the writer is aware, upon long dust chambers for the collection of fume and dust. The copper smelters at Butte, Montana, have few flues and those are generally very short. The Parrot smelter at Butte, Montana, had a system of collecting chambers in connection with their bessemerizing plant, which, although very limited, did collect very valuable material. There is a long flue at the Great Falls Copper Smelter, connecting the furnaces with a high stack placed at the top of a high hill.

The lead smelters at Leadville, Colorado, depend chiefly upon flues, but they are all short and simple in construction. The Lewis-Bartlett bag house patented process was tried at the old Grant Smelter at Leadville upon one furnace, but this process did not receive recognition, and its use did not extend to other smelting establishments, and was abandoned by this company. The Argo works, at Denver, Colorado, have few, if any flues, owing to the fact, presumably, that copper is not considered a volatile metal, there may be other good reasons for not using flues or some system for collecting fume and dust not known to the writer.

All the Pueblo smelters treating argentiferous lead ores use simply some style of dust chambers.

Mr. W. H. James, the Superintendent of the Omaha and Grant Smelter, has taken out a patent involving the use of hollow terra cotta tile for the construction of a long system of chambers having six compartments, which causes the smoke to travel back and

forth before finally issuing from a stack 350 feet high and having an internal diameter of 14 feet. These tile are supported by twisted iron for the roof, the sides are braced with brick piers, and the gases are cooled down from the top, sides and bottom of the chamber by suitable air ducts or passage ways. This method is peculiar to these works and is generally believed to be highly satisfactory.

The Globe Smelting and Refining Company, of Denver, Colorado, have long flues constructed, both of iron and brick, and in addition thereto they operate under the patents of The Western Patent Company of Denver, Colorado.

A large number of valuable patents pertaining to fume collection are owned by this company, among others the celebrated patents of O. Lewis and E. O. Bartlett, known as the Lewis-Bartlett Bag House Patents. The Petraeus patents are also included, and likewise those of Mr. Dennis Sheedy, Mr. A. Chanute and nine by the writer.

We, therefore, see from the above statements that where any attempts have been made in this country to save both fume and dust the long chambers have up to the present time received the most recognition.

Division B.

Brush-wood has been used for the collection of lead fume by placing it in flues, towers or chambers. In the early history of lead metallurgy it was extensively used in England, but has now been entirely abandoned throughout the world.

Dry coke has been used at certain places and, as can be readily seen, does afford a very considerable surface exposure and a saving is no doubt effected for a limited period of time. The trouble, however, in its use is due to the fact that the intersticies or coke cells readily become clogged, and instead of a porous material, exposing a large surface it soon becomes no better than a cobble stone.

Furthermore the material which is collected is in a bad form to handle and treat, unless it be burnt in the blast furnace in the dry condition and even then it would not be a desirable product.

The writer is of the opinion that both brush-wood and coke are most excellent examples of "*what not to do.*"

Screens of iron, copper or other metal wire have been suggested,

and patented without even a trial in many cases, and have always been found highly unsatisfactory. Various revolving screens have floated through the minds of patentees, reversible screens likewise have claimed the attention of parties not having a true and proper conception of the subject.

The use of water in a constant or intermittent stream has been tried from time to time, and has never yet given satisfaction for long periods. It is very difficult to cause a perfect mixture of water and flue dust for a number of reasons, which it is not pertinent to discuss at this particular time. Although a large number of water methods have been suggested and tried, they have eventually been given up, owing to the very large number of difficulties constantly arising in the practice of the same, which were not thought of until too late. The writer has had a long practical experience with these water methods and is disgusted with all of them.

At the Balbach's Works at Newark, N. J., the method they were using in 1890 may be briefly described as follows: The dust from their blast furnaces passed through an inclined pipe into the top of their dust chambers; this smoke after passing around a sharp curve enters a large chamber divided by a brick wall, causing the smoke to rise up near the roof. It then descends to the bottom of the chamber through an opening into a second chamber, which has at three feet above the floor line a series of wire screens made of round wrought iron, spaced about one inch apart. Upon this wrought iron grating is placed from 18 inches to 2 feet of coke. Above this coke, and in the same chamber with it, is placed a series of pipes having attached simply the nozzles of ordinary but large garden sprinklers spraying the water down upon the coke. A certain portion of the fume rising through this coke and sprayed by water is caught, and drops to the bottom of the chamber where it finally runs out over a brick wall into an exterior chamber from which it is pumped by means of an ordinary hand pump into various receptacles, but usually over fine ore. This ore is then charged directly into the blast furnaces.

The writer is not favorably impressed with any of the methods to be found in Division B.

Division C.

Steam has been tried a great number of times in a great number of places, and has been or should be abandoned. Dr. Percy

states that while the rationale of this process seems very feasible, yet the steam, instead of being depressed upon the fume, is in fact borne along and eventually comes out of the stack. Patents after patents have been taken out for the use of steam for condensing lead and other fume, or so-called flue-dust, all of which we believe to possess little or no merit.

One of the greatest troubles in the use of steam is found in the fact that the fume from the roasting furnaces contains a large amount of sulphurous acid, and the fume from the blast furnaces also contains a certain amount of sulphurous acid, which is readily converted by the steam into sulphuric acid, and this acid not only corrodes the mortar and the brick in time, but also the iron which it comes in contact in the dust-chamber.

We are now led to discuss the use of water in the shape of drops or jets projected with some considerable degree of force into or across the current of the smoke. This was at one time a favorite method of the writer, who worked about two years in this direction, experimenting upon all sorts of devices and schemes which would break up the water into a fine state of division. My object was to obtain particles intermediate between large drops and steam. I succeeded in perfecting a large number of these devices, some of which were unique, many of them entirely practicable so far as operation was concerned, but after a long practical trial upon a large scale I have now entirely abandoned them all, as the sulphuric acid water will surely destroy the mortar; the bricks will be greatly impaired; and the stack constructed either of brick or iron weakened. Possibly if the chambers could be constructed of sheet-lead, and the stack lined with sheet-lead also, that fairly good results could be obtained. It would be entirely possible to use a fan constructed of some material which would not be attacked by the sulphuric acid, since in this case a strong positive draft could be at all times maintained. Whilst the method has great possibilities, yet it does not arouse enthusiasm, owing to chemical and mechanical difficulties.

The use of large drops of water has been practiced for over a century, and it is upon this principle, together with an additional cooling surface, that the method at one time practiced at the St. Louis Smelting and Refining Company was based, and which has earlier been referred to in this paper. This method can be briefly described as follows: All the smoke from the blast furnaces was

made to pass through one long underground flue, having a tortuous course; the smoke finally entered into a brick chamber, built upon the top of the ground, which is 10 feet wide by 20 feet long, and about 12 feet high.

The smoke was made to rise upright by means of a four-inch partition wall running up nearly to the roof of the chamber.

After passing over this four-inch wall it was caused to descend through a series of four-inch drain tiles placed one upon another, which tiles are properly supported upon 2x6 inch plank, which in turn rest upon 65 pound railroad iron.

The smoke passing through and around this 4-inch tile is sprayed by water from above, the water passing within and without the tiles, washing down the dust. After the smoke has passed through this first series of tiles it passed through a second series of tiles rising up through them, and spray nozzles are used above in this case also. The smoke then rises and is withdrawn by means of two 90-inch Sturtevant fans, and is then forced through a long wooden box or tank having hanging curtains, causing the smoke to come near and in close contact to the water in the tank. The smoke in this wooden box is sprayed from above.

There is comparatively a short length of chamber leading from this spray box to the brick stack, from which only a trifle of white misty fog was perceptible.

The use of drain tiles is quite unique, and the writer believes worthy of careful consideration. Whether the fan should be placed so as to take the smoke after leaving the tile chamber, or before entering the chamber is an open question; it would seem, however, that if the boilers, engine and fan were placed compactly together and the smoke issued from the underground flue directly into the base of the fan, and the smoke were then forced through a series of tile chambers, a somewhat better arrangement would be obtained. A most excellent arrangement is to have the chamber leading from the fan widen out to a double chamber, and upon the central wall hang a good and secure gate operated from the outside with a powerful handle, and to place the same kind of gate at the other end of the central wall. The fume can then be switched into either chamber as desired. Each chamber could be divided into any number of compartments or rooms, and be of any desired length, each room to be filled with 4, 6, 8 or 10 inch tiles sprayed from above. Either would admit of easy and quick access at any and

all times during the operation of the other and without interference with the furnace from one year to another.

With powerful fans and sufficient length of flue all fume and dust could be completely collected by this system, irrespective of the nature of the material. Of course, the writer appreciates that proper provision should be made for quick methods of filtration, and for causing the smoke to rise and fall at intervals through the tile. By lining up the inner walls with glazed brick, using heavy-spar mortar, we could obtain a structure which would not need any repairs for a very long time.

Divisions D. & E.

Under this head the smoke is caused to pass through a depth of water either in great volumes or in a more or less divided condition. This has always been a total failure, and is now nearly if not altogether obsolete. We will say in passing that under this division the Patent Offices, both in this and other countries, particularly England, are filled with applications bearing upon this subject, and are likely to keep up this business indefinitely. One of the best and most ingenious of all of these patents is the Stagg Condenser, in which the smoke was forced underneath the surface of water by means of powerful pumps. Experiments were made by Messrs. A. French, H. J. and J. W. Wilson, for the Sheffield Smelting Company of England, in which they found that the mere bubbling of smoke through water from a perforated pipe added but little in saving fume. They made experiments proving this statement, which literally quoted, is as follows:

"In the large one we passed the smoke through a number of horizontal perforated pipes submerged eleven inches in water. Our assays showed that only 30% of the fume was arrested. Our experiments on a smaller scale gave even worse results." They proved the fume was difficult to wet (*i. e.*, lead fume) by coating a glass plate with it and then dropping water on it, while it was held at an angle of 60° to the horizon; the drops were deflected off without wetting the plate. Equal quantities of smoke were bubbled through a wash-bottle arrangement filled first with water, and then with ordinary rape oil. The oil, which has less than half the surface tension of the water, caught three times as much fume as the water. Years ago the late F. C. Blake, of the Pennsylvania Lead Works, recognized that there were other substances

or liquids much better than water. Many of these he tried and he showed the writer an extensive experiment that he had conducted using pyroligneous acid. The writer regards this gentleman as one of the most progressive thinkers upon this subject we have ever had in this country. All of Blake's accumulated literature was placed in the hands of the writer.

The experiments of A. French and the Messrs. Wilson led them to seek for some way of breaking up the surface tension of the bubbles, and the result was they hit upon the device of using fine wire gauze made of any metal capable of resisting the corrosive action of sulphurous acid. Copper-gauze answered perfectly. We quote verbatim as follows:

"We used wire gauze having about 15 meshes to the linear inch, the meshes being about 1-20th of an inch wide. A number of gauze diaphragms were arranged one above another in horizontal planes and at small distances apart. The whole are submerged in water. The smoke is equally distributed under these by means of a horizontal series of perforated pipes. The depth of water usually employed is 7 inches above the perforated pipes, and with this depth the water guage indicated a resistance of about 10 inches, half an inch only of which is due to the gauze, the remainder being due to the depth to which the smoke depresses the water at the inlet passages.

They used a Root's Blower with iron revolvers for forcing the smoke through the apparatus, and they claim that from 2½ to 3 horse-power is amply sufficient to work a condenser large enough for a furnace to smelt 15 tons of lead ore per 24 hours. They say the smoke should be cooled to about 120 or 130° F. by passing it through iron pipes or any other kind of flue. As to the saving effected by this devise, we note it is simply astounding. For example they say: "During the past six months almost daily assays have been made of the smoke before it entered and after it left the condenser. These have with a few exceptions exceeded 95% of the fume caught. The average has been 98% and in a few cases 99% of the metallic contents." It is a pity they did not give the full method by which they made their "*assays*," as they term them, and the method they adopted for collecting all of the smoke for analysis.

This method is worthy of careful thought and experimentation, even though the product collected is not viewed by the writer as

existing in a very desirable form and many mechanical difficulties would have to be overcome, for example in handling 250,000 cubic feet of gas per minute, an amount many metallurgists in this country have to deal with.

Division F.

We have little to add upon this division, which comprises metallic plates hung in flues parallel to their length, except that they are reported to have proven a success at Ems, Germany. The writer has tried them, and abandoned them because of insufficient length of chamber and insufficient draft. Mr. E. F. Eurich also claims they can only be used successfully in long chambers.

For a full description of this method the readers of the QUARTERLY are referred to a paper of much merit by Dr. Thos. Egleston, entitled: "The method of collecting flue-dust at Ems, on the Lahn," read at the Boston Meeting, February, 1883, of the American Institute of Mining Engineers. There is also a comprehensive article on this subject in the *Engineering and Mining Journal*, July 1, 1882.

Division G.

It has been a matter of much surprise and wonderment to the writer that the subject of the condensation of metallurgic fume by static electricity has not received more attention in this country. It is believed graduates of colleges who are seeking some field for original thought and work would find in this subject a most flattering and fertile field. Furthermore, the young army of electricians who are yearly springing up, would, in the opinion of the writer, find in this subject much which would be of great financial interest to themselves and their associates.

We believe this subject has been very much neglected—possibly overlooked and forgotten — and the readers of the QUARTERLY will find an interesting article on it in the *Scientific American*, June 27, 1885, extracted from *Engineering*, which describes the experiments carried on by Mr. Alfred O. Walker, of Chester, England, and Prof. Lodge,* of Liverpool. These experiments dealt with the effect of a discharge of high tension electricity from a point or points into glass jars containing dust in suspension. The discharge caused a rapid settling of the dust, which, if left to

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itself, would have taken hours to settle. Magnesium oxide and smoke from burning paper or cigar were used.

Experiments were made on a larger scale, rooms being filled with smoke and rapidly cleared in the above manner.

Mr. Walker, in conjunction with Prof. Lodge, built special flues at the works of Walker, Baker & Co., at Bagillt, North Wales, to ascertain the practical effect of discharging high tension currents through the lead fume from the furnaces. The first experiments were tried upon the lead fume in a quiet state. This fume, when left to itself, took hours to settle, but when the electric machine (built on the Voss system with an 18-inch diameter glass plate) was set to work the same actions took place as with the magnesia in the glass jar. Through a glass window in the flue could be observed the whirling movement around the discharge points, and in a few seconds the fog was seen changing into little flakes, like snow flakes, which rapidly flew to the side of the chamber and were there deposited in a very short time, the atmosphere of the chamber becoming as clear as before the fume was let in. Experiments were then tried with the fume in rapid motion the whole pressure of the furnace gases were passed through the experimental flue and allowed to stream into the air. At the outlet, a few seconds after the electric discharges were commenced, a very striking effect was observed, the issuing fume again being changed from fog to flake, much of it being agglomerated and, at times, when the weather was perfectly calm some of it would fall to the ground immediately on leaving the exit opening of the flue. Experiments on various arrangements of discharge points seemed to show that within certain limits prescribed by the power of the machine in use, the more points employed the better. Mr. Walker decided to apply this method of fume condensation on a full working scale, treating the fume from 19 furnaces at the Bagillt works.

Full details of the method of operating are given in the text of the article, but as Mr. Walker's fine hopes and expectations were not realized the reader is referred to the article itself for particulars.

In the *Scientific American* for April 3, 1886, is an article extracted from "*La Lumiere Electrique*," by E. Dieudonné, entitled "The condensation of fumes by static electricity." This contains a summary of the results obtained by Mr. Aitken and others, dealing mainly with the subject of fog. The most striking experiment was made with two glass receivers, one filled with ordinary air and

the other with air purified with great care and filtered through wadding. By cooling, the aqueous vapor in the first vessel condensed in the form of fog while the second receiver preserved its transparency. In the strength of these experiments Mr. Aitken makes the assertion that without the presence of dust in the air neither fog nor clouds would form and probably no rain.

Other laboratory experiments by Messrs. Clark and Lodge are quoted.

Dr. Oliver J. Lodge delivered a lecture to the Royal Dublin Society, April 2nd, 1884, upon "Dust-free Spaces." In this lecture the doctor says: "It so happened that at the time I received a request from the Secretary of this Society to lecture here this afternoon, I was in the middle of a research connected with dust, which I had been carrying on for some months in conjunction with Mr. J. W. Clark, Demonstrator of Physics in University College, Liverpool, and which led us to some interesting results." Dr. Lodge then proceeds to define dust, smoke and fog, and gives interesting facts and data about clouds and mist; he points out two principal methods for the recognition of dust in the air; and in order to make clear what is meant by "*dust free spaces*" he gives the highly interesting experiments of Dr. Tyndall, made in 1870. He says whilst Dr. Tyndall was examining dusty air by means of a beam of light in which a spirit-lamp happened to be burning, he noticed that from the lamp there poured up torrents of apparently thick, black smoke. He could not think that the flame was really smoky, but to make sure he tried first a Bunsen gas flame and then a hydrogen flame. They all showed the same effect, and smoke was out of the question. He (Tyndall) then uses a red-hot poker, a platinum wire ignited by an electric current, and ultimately a flask of hot water, and he found that from all warm bodies examined in dusty air by a beam of light the up-streaming convection currents were dark. Now, of course, smoke would behave very differently. Dusty air itself is only a kind of smoke, and it looks bright, and the thicker the smoke the brighter it looks; the blackness is simply the utter absence of smoke; there is nothing for the air to illuminate, accordingly we have the blankness of sheer invisibility."

Dr. Lodge further adds: "*Why* the convection currents were free from dust was unknown; Tyndall thought the dust was burnt and consumed; Dr. Frankland thought it was simply evaporated."

This matter then rested until 1881, when Lord Rayleigh took the matter up and repeated all the experiments of his predecessors with heated bodies, and the thought came to him that if *hot* bodies showed this peculiar phenomenon, then what would *cold* bodies show under like circumstances? Lord Rayleigh first discovered that from the cold body the descending currents were *just as dark and dust-free as from a warm body.* Therefore, the combustion idea of Tyndall and the evaporation explanation of Frankland became untenable.

Dr. Lodge and Mr. Clark took the matter up during the summer of 1883 and critically examined all sorts of hypotheses that suggested themselves. We learn the true nobleness of the character of Dr. Lodge, who proves to us how unselfish he is by sharing a great discovery with his fellow-worker, Mr. J. W. Clark. Dr. Lodge says: "Mr. Clark followed up the phenomena experimentally with great ingenuity and perseverance. One hypothesis after another suggested itself, seemed hopeful for a time, and ultimately had to be discarded. Some died quickly, others lingered long." The results of these scientists may be briefly stated as follows:

Surrounding all bodies warmer than the air is a thin region free from dust, which shows itself as a dark space when examined by looking along a cylinder illuminated transversely, and with a dark background. At high temperatures the coat is thick; at very low temperatures it is absent, and dust then rapidly collects. On a warm surface *only the heavy* particles are able to settle. An excess of temperature of a degree or two is sufficient to establish this dust-free coat, and it is easy to see the dust-free plane rising from it. There is a molecular bombardment from all warm surfaces by means of which small suspended bodies get driven outward and kept away from the surface. It is a sort of differential bombardment of the gas molecules on the two faces of a dust particle. Near cold surfaces the bombardment is very feeble, and if they are cold enough it appears to act toward the body, driving the dust inward, hence bodies colder than the atmosphere surrounding them soon get dusty.

* * * * * * *

How easy it is now to see why hanging sheet iron plates in a dust-chamber has but little benefit where the temperature is too great, resulting from insufficiency of dust-chamber. Are we not

here taught that these iron plates which quickly become heated will only collect the large particles and not the fume. We understand why the practical experiments of Eurich and Iles failed; the plates were too hot.

Dr. Lodge leads his hearers along in a clear logical and convincing manner and then makes use of the following ever memorable words:

"But we have found another and apparently much more effectual mode of clearing air than this. *We do it by discharging electricity* into it. *It is easily possible to electrify air by means of a point or flame, and an electrified body has this curious property, that the dust near it at once aggregates together into larger particles. It is not difficult to understand why this happens; each of the particles becomes polarized by induction, and they then cling together, end to end, just like iron filings near a magnet. A feeble charge is often sufficient to start this coagulating action. And when the particles have grown into big ones they easily and quickly fall. A strong charge forcibly drives them on to all electrified surfaces, where they cling.*"

Dr. Lodge experimented at his lecture upon the following material: Fine water fog, smoke, magnesia burnt in an electrified jar, smoke from turpentine and the same with turpentine. All these he used on a large scale. He states that "a room filled with turpentine smoke, so dense that a gas light is invisible inside it, begins to clear in a minute or two after the machine begins to turn, and in a quarter of an hour one can go in and find the walls thickly covered with stringy flakes, notably on the gas pipes and everything most easily charged by induction." He also experimented upon steam and upon an artificial London fog, and states that the air of tunnels can probably be thus cleared. In all probability he experimented upon a vast number of so-called smokes, fumes, fogs and mists, which he did not mention.

I recently wrote to Professor Lodge making inquiry about the method of condensation of metallurgic fume by the use of static electricity, which was patented by Mr. Walker, and inquired how it was getting along, and whether it had been vigorously prosecuted. His reply states that as far as then known it was not in use in England.

I am also in receipt of a letter from Mr. W. M. Hutchings, dated June 9, 1895, as follows:

DEAR SIR: I am away spending a few weeks' holiday, and your letter is sent on to me here.

As far as I am aware, *no* use has yet been made in practice of the electric condensation of fume. I am often on the Continent, and I have not heard of any application of it.

We gave it up in Wales, after very long trials and every effort to make it "go." I carried out all these experiments, and was in the beginning very hopeful that we were going to have a great success. It *was* a success as long as we worked on small volumes of fume either enclosed in small holders (such as a large cask or box) or even when fume passed slowly through such holders. But we never succeeded in any way as soon as we got to work on the actual flues, in which great masses of gas were in rapid motion. We had a very powerful machine specially made and driven by an engine, and we varied in every way the conductors and the points by which we got the discharge into the passing gases. But it was all in vain, and equally so when we worked on a smaller branch flue, which we made with windows for observation.

Our conclusion was that it was the *speed* of the gases which was mainly in our way, as we did not find any better results in *cool* flues than in *hot* ones, and we made ourselves quite sure that it was not the *moisture* which caused failure.

At any rate, we gave it up finally, as we saw that we could make nothing of it under the actual conditions of our works; and we were not able to modify these conditions in any important degree.

My own belief is that, rapid as is the condensing action of the discharge, whenever it *does* succeed there is still such a distinct amount of *time* necessary for the charging of the particles and their mutual attraction that the gases in any wood flues must always travel at such speed that there is not time for the action to take place.

I do not, however, regard our trial as having been at all complete, and I think that there is room for a further examination. I hope you are going to take it up, and shall be heartily glad if you succeed. Yours very truly,

W. M. HUTCHINGS.

M. W. ILES, ESQ.

A careful perusal of Mr. Hutching's letter develops the fact that one of the chief causes for the disappointing results obtained was due to the velocity of the gases when he operated upon a practical

scale; the smoke passed through his chambers too rapidly. We do not know the cross sectional area of his dust chambers, nor do we know how many feet per minute the gases traveled; yet this fact can of course be readily obtained in any dust chamber or flue by the use of an anemometer. There is an English anemometer made in London which is particularly adapted for ascertaining velocities in flues. An anemometer is as indispensable in works producing or generating fume of value as a clock. It is the frequent use of this instrument, which has caused the writer to make the criticism that practically all flues about metallurgical establishments are too small.

When one stops to actually figure how slight is the increased cost of a dust-chamber by the addition of a few more bricks in the arch, and takes into consideration the fact that the side walls are the same whether the chamber be 2 feet wide or 12 or more feet wide, then it becomes a matter of great surprise that the mistake has been so often made of building the flues too small. Plainly, then, ways and means must be devised for making the gases travel slowly. How can we construct a dust-chamber so as to make the gases travel slowly? There are many ways of doing this, but how can we do it without an interference with the draft of the furnace? To merely enlarge the flue at one particular point does lessen the velocity of the outgoing gases, but there will be through the center of the chamber and in a straight line a greater rapidity than on the sides and away from this line.

The most satisfactory way for lessening the velocity of gases in flues the writer has ever heard of is mentioned in the Proceedings of The (English) Institution of Civil Engineers, Vol. cxii., Session 1892–'93, Part ii., during meeting of January 31, 1893.

Paper No. 2655 in an article by Henry Francis Collins, entitled: "Smelting Processes for the Extraction of Silver and Gold from their Ores." During this same evening there was read Paper No. 2583, entitled: "The erection of Silver-Lead Smelting-Works in Mexico," by J. W. Malcolmson. During the discussion of these interesting papers Mr. E. A. Cowper said: "The second point that he wished to refer to, was the saving of "fume" from such furnaces as those described in the papers, or from lead or from Scotch furnaces.

The plan resorted to in the works described followed the common old-fashioned idea of a long flue from the furnaces to the

stack, and sometimes combined with chambers. That was a mistake, even if the flue were very long (it was sometimes ¾ mile in length), for the draught through the flue kept by far the greater part of the fume in motion, and carried it out at the top of the stack; but if, on the contrary, there was but a slight draught and the fume and gases moved along very slowly, say, at one-twentieth the speed in an ordinary flue, the fume would deposit in large

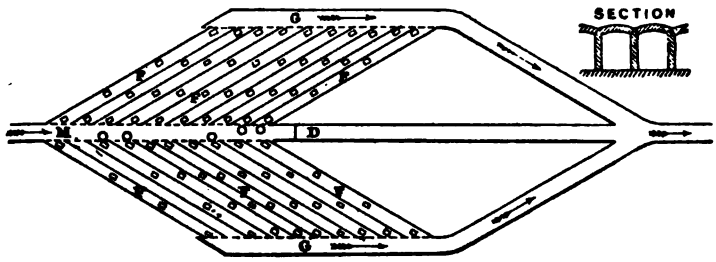

FIG. 1.

quantity. The plan might be carried out in various ways, but a convenient one adopted by him was shown in *Fig. 1*. A large number of parallel flues F F F were placed on each side of the main flue M, to the stack. Those flues were situated at an angle to the main flue, and each had a small opening into it, so that it should only take its fair share of the draught; then the outer ends of each set of parallel flues were connected to a gathering-flue G, which, being connected with the main flue beyond the system, and a door D being shut in the main flue, obliged all the fume to be distributed equally through the parallel flues, and such products of combustion as were not deposited found their way by the gathering-flues G G to the main flue at the stack. This plan he had put before his friend, Mr. Sopwith, some years ago, and it had been at work most successfully in Spain since 1882. There had been an inspection of the works by an independent officer on the part of the Patent Office to report whether the plan was at work. From that gentleman's report it appeared that 190,000 lbs. of fume were deposited in 6 months, and that the arrangement was most effective. He had a further report of an extension of the plan to more furnaces, and in 8 weeks there was deposited on an average

3 feet depth of fume in the flues; and as the flues covered a good deal of ground, an enormous amount was thus obtained. The fume contained about 67 per cent. of lead. An incline had been arranged to convey this large quantity of fume more conveniently back to the furnaces for treatment. In the case of the gold and silver works, the fume would not only contain lead, but gold and silver."

The writer is heartily in accord with Dr. Oliver J. Lodge in his statement: "It is a pity some one does not take the matter up and run it to a success." I have conceived the idea that it can and will be made a success sooner or later, not only for the collection of metallurgic fume, but also for hundreds of other purposes which we no not now dream of in the lines of improving the sanitary conditions of the world.

DIVISION H.

Filtration through cloth or other textile fabrics:

For certain good business reasons I cannot discuss this subject or state any facts pertaining thereto. As a matter of record I will, however, state such literature as I have been able to accumulate: Hofman's "Metallurgy of Lead," page 124. Hofman cites the following references: Dewey, *Transactions American Institute of Mining Engineers* XVIII., page 674; Clerc, *Engineering and Mining Journal*, July 4, 1885; Ramsay, *Scientific American Supplement*, May 14, 1887, No. 593.

I add the following: U. S. Geological Survey, Clarence King, Director, "Geology and Mining Industry of Leadville, Colorado," by S. F. Emmons. In this treatise we find an article under Appendix C, Metallurgy, by Antony Guyard, on page 673, entitled, "Bartlett Filter."

The Journal of the Franklin Institute, Vol. XCI., No. 541, page 128. This article is entitled: "On Some of the Conditions of Loss by Volatilization in Certain Metallurgical Operations," by Charles P. Williams.

"Treatment of Galena Ores in Joplin, Missouri," by C. V. Petraeus. *Engineering and Mining Journal*, February 3, 1894.

"The F. L. Bartlett Zinc-Lead Process." *Engineering and Mining Journal*, December 9, 1893. An article published in the *Journal of the Society of Arts*, copied in *The Popular Science Monthly*, this article is entitled: "Dust and Fresh Air," by T. Pridgin Teale, F. R. S., Vol. XLI., 19.

The *Engineering and Mining Journal*, December 8, 1894, page 535; also *Engineering and Mining Journal*, October 28, 1893. In the St. Louis *Globe Democrat*, October 19, 1887, there is found an article as follows: "The Only Works in the Country which Turns Furnace Fumes Into White Lead. Joplin's Two-Fold Reduction. A Process which saves all but the Gas. The Jerseyman's Discovery. Two Ex-Kings."

Although the head lines are strictly in accord with American Journalism, yet the data here presented is both interesting and valuable.

PERMEABILITY OF IRON AND STEEL.

By MAX OSTERBERG E. E.,

Fellow in Mechanics, Columbia College.

Introductory. A solenoid carrying an electrical current will produce magnetism in its core. We can then speak of magnetism permeating the space, and experiment tells us that the amount thus permeating depends largely on the material which occupies that space. Interposing iron, we find the magnetism produced with a given current flowing through a given solenoid very much stronger than if we interpose wood, copper, or simply air. In fact we observe that all materials act practically alike, except iron, nickel and cobalt. Of these three, iron is the most important, possessing this property in the first place to a very much higher degree and being in the second place cheaper and more useful in the arts. We shall therefore devote our attention entirely to iron and steel.

Since we speak of magnetism permeating the iron core, we can speak of iron having a certain permeability, and define this term in its technical sense as:

1. A number.

2. A ratio, expressing the relation between the magnetism generated in a certain solenoid, whose core is of air, and a similar solenoid, whose core is of iron.

3. It is therefore "specific" magnetic conductivity.

Object of investigation. So much by way of introduction. Before going any further it is desirable to point out the importance of careful investigation in this field, by pointing out its usefulness.

Electrical Engineering, undoubtedly more than any other branch of engineering, allows of an extremely sound mathematical basis. The accuracy with which the efficiency of any piece of machinery can be predetermined is in many cases perfectly marvelous, and in every case where perfect accuracy cannot be obtained it is due, either to a superficial or rather inaccurate knowledge of mechanical details or, to the imperfect knowledge of the permeability factor of the iron used. So for instance, is the electromotive force of a dynamo easily determined, since it depends simply on three factors:

1. On the number of conductors on the armature.
2. On the number of revolutions of the armature per second.
3. On the number of lines of force cut per second.

By lines of force we mean a certain magnetic flux, the term "lines of force" being used in electrical engineering in the same way that the hydraulic engineer uses the term "lines of flow" only with one additional meaning. Lines of force do not only express direction but also intensity of magnetization.

The first two of those factors are of course perfectly definite, while the latter depends entirely on the kind of iron or steel used in the different parts of the magnetic circuit. But it is not even sufficient to know the number of lines of force at any given moment, for we may want to vary the electromotive force without changing the speed of our machinery; in that case the current flowing through the solenoids, which in the case of a dynamo are the field coils, must be varied in such a way as to regulate the electromotive force of the dynamo; since different qualities of iron and steel vary in a different way in their magnetic properties, we have practically to regulate our dynamos by experiment. This method, although fairly practicable, is not the most desirable and a thorough study of the law of variation of permeability is therefore obviously shown to be of great importance. Let us therefore investigate the causes which influence the magnetic qualities of iron.

Causes of Variation of Permeability. We find the following to affect the permeability of iron:

1. Chemical composition.
2. Temper.
3. Temperature.
4. Rapid magnetizing and demagnetizing (frequency).
5. Previous history.

General Law of Permeability. To explain the general way in which the permeability variation takes place, the writer has selected a curve, which, although quite useless in any specific case, is very memorable for its historical value. It is the so-called Hopkinson wrought iron curve and was obtained by John Hopkinson in 1885 by taking the average of 35 different samples of wrought iron wire. (Fig. 1.)

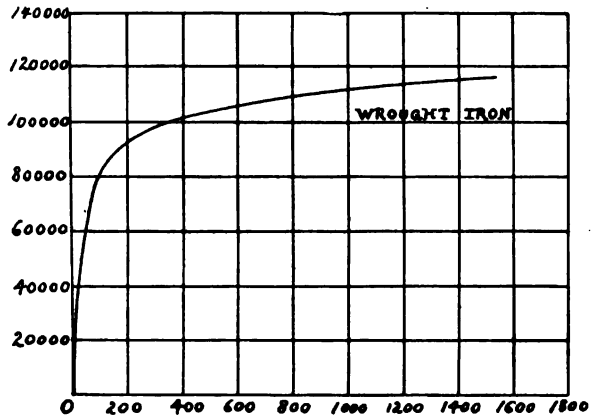

FIG. 1.

The ordinates represent the number of lines of force per square inch, that is the magnetic induction, the abscissæ represent the magnetizing force.

Magnetizing force is equal to

$$\frac{\text{constant} \times \text{current} \times \text{turns of wire in solenoid}}{\text{length of magnetic circuit.}}$$

In text books this is given thus:

$$1.257 \frac{S\,I}{l}$$

where S — number of turns of solenoid
I — current in amperes
l — length of magnetic circuit

As a matter of fact the length of a magnetic circuit is very hard to determine, except in special cases, namely, where the entire circuit is of iron or has at least very short air gaps.

By inspecting the diagram it can be easily seen that with low magnetizations, say from zero to 60,000 lines of force per square inch, it takes but a very small magnetizing force to produce a considerable amount of magnetization. Then we arrive at what is usually termed the *knee* of the curve, where the force to be applied

in order to increase the magnetization increases very rapidly indeed; finally with an intensity of about 100,000 lines of force per square inch a very considerable increase in magnetizing force will produce practically no increase in the magnetization. This general law holds for all kinds of iron and steel, with these differences:

a. In Cast Iron. Before reaching the knee, the angle of inclination towards the abscissa is smaller, the knee has a greater arc towards the abscissa and the practically straight line is reached at about 40,000—60,000 lines of force per square inch.

b. In Soft Steel. This curve rises a little faster than the ordinary commercial wrought iron curve; it cuts the conventional wrought iron curve, shown in figure 1 usually just below the knee, then again right beyond the knee and approaches a straight line shortly after. This phenomenon has been observed by various experimenters during the last few years and finds various commercial applications.

c. Hardened Steel. This is only of interest as far as experiments are concerned; it is practically useless for electromagnets, since it does under no condition allow of a strong magnetization.

Special Cases. To study the detailed variations we must take individual samples and test them when their composition and temper is known. The samples here quoted were kindly furnished by the Bethlehem Iron Company and formed part of that company's exhibit at the Chicago World's Fair. The investigation formed part of the writer's graduation thesis and was published in the *Electrical World* July 14, '94.

Four samples which were treated by the Basic Open Hearth Steel Process had the following impurities:

Carbon	.07 %
Manganese	.22 %
Phosphorus	.008 %
Sulphur	.032 %
Silicon	.053 %

This quality is denoted in our curves by " 10," and we have in all four curves, showing the effect on the permeability of 1, ordinary cooling (10). 2, Annealing (10 S). 3, Hardening and then Annealing (10 H. S). 4, Hardening (10 H). Several points were selected to determine the average curves for these experiments, and they show the following relations between the total induction per

square centimetre, marked B or per square inch marked B″ and the premeability "μ" under a magnetizing force "H."

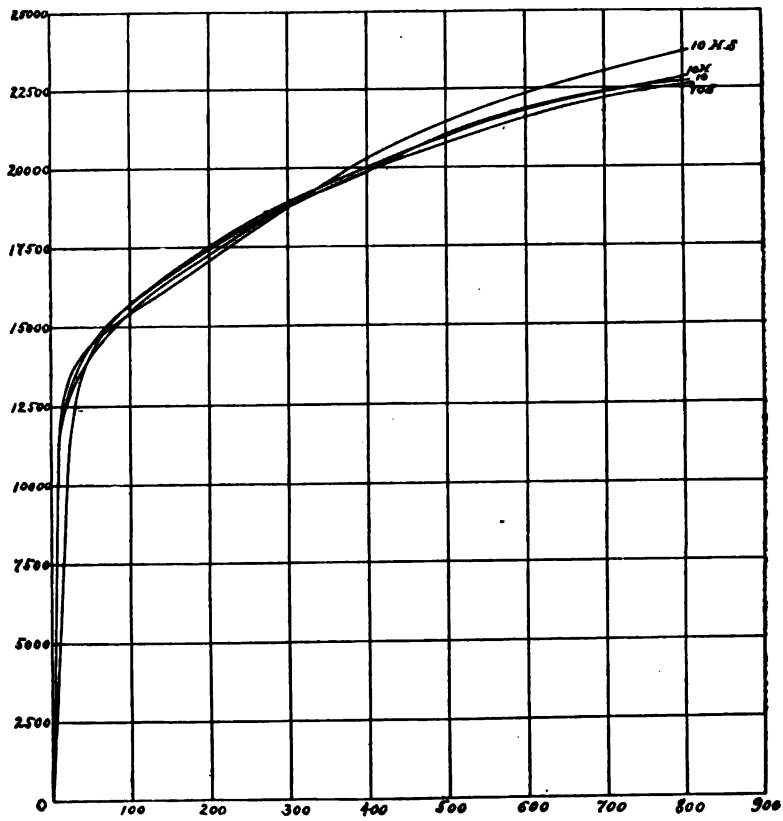

FIG. 2.

SAMPLE NO. 10.

	B	B″	H	μ
1	11.466	73.956	12.4	927
2	13.883	89.546	38	362
3	14.721	94.950	62	238
4	16.114	103.935	124	130
5	17.943	115.732	249	72
6	19.616	126.523	384	51
7	21.630	139.514	618	35
8	22.506	145.164	750	30

SAMPLE NO. 10 S.

	B	B″	H	μ
1	9.110	58.760	8.67	1.052
2	11.498	74.162	12	929
3	14.626	94.338	74	197
4	15.992	103.148	124	129
5	17.852	115.145	248	72
6	19.526	126.007	369	53
7	21.693	139.920	620	35
8	22.592	145.718	753	30

SAMPLE 10 H. S.

	B	B″	H	μ
1	11.219	72.363	11	1.007
2	13.574	87.552	28	488
3	14.689	94.744	62	237
4	15.371	99.143	96	160
5	16.052	103.535	139	115
6	16.982	109.534	200	85
7	21.631	139.520	515	42
8	23.341	150.549	753	31

SAMPLE 10 H.

	B	B″	H	μ
1	5.422	34.972	12	438
2	13.387	86.342	37	361
3	15.000	96.740	74	202
4	16.177	104.342	124	131
5	18.253	117.732	247	74
6	20.948	135.114	499	42
7	22.066	142.326	613	36
8	22.655	146.125	743	30.5

Another set of four which was treated by the Acid Open Hearth Process had the following impurities:

Carbon,	1.406 %
Manganese,	.470 %
Phosphorus,	.032 %
Sulphur,	.032 %
Silicon,	.077 %

This quality is denoted in our curves by 140, 140 S., 140 H. S. and 140 H.

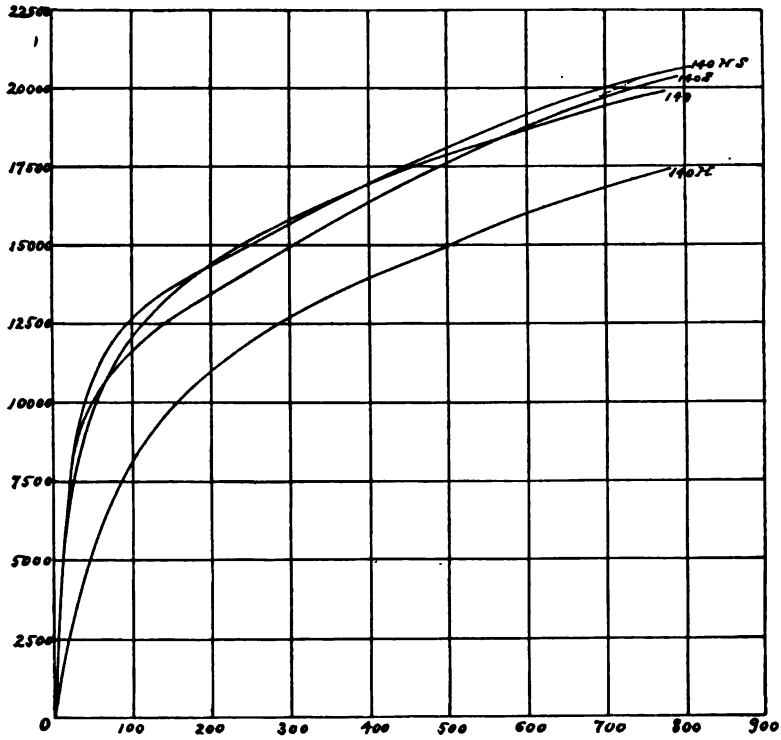

FIG. 3.

SAMPLE 140.

	B.	B″.	H.	μ.
1	3.946	25.452	319	12
2	8.863	57.166	239	37
3	10.165	65.564	164	62
4	13.078	84.353	106	123
5	15.080	97.266	61	247
6	16.444	106.064	44	374
7	17.665	113.939	36	490
8	19.068	122.989	30	635
9	20.050	129.323	27	743

SAMPLE 140 S.

	B.	B″.	H.	μ.
1	4.401	28.386	11.2	395
2	7.685	49.568	21	363
3	9.607	61.965	37	265
4	11.403	73.549	89	128
5	12.520	80.754	133	94
6	13.263	85.546	192	69
7	14.008	90.351	250	56
8	16.393	105.735	381	43
9	17.757	114.533	507	35
10	18.904	121.931	610	31

SAMPLE 140 H. S.

	B.	B″.	H.	μ.
1	7.996	51.574	25	323
2	11.498	74.162	62	186
3	13.203	85.159	124	107
4	14.972	96.569	250	60
5	16.735	107.941	372	45
6	17.807	114.855	495	36
7	19.090	123.131	616	31
8	20.080	129.516	717	28
9	20.203	130.309	748	27

SAMPLE 140 H.

	B.	B″.	H.	μ.
1	4.550	29.348	49	92
2	8.554	55.173	124	69
3	11.682	75.349	249	47
4	13.426	86.598	373	36
5	15.060	97 137	502	30
6	16.152	104.180	621	26
7	17.231	111.140	749	23

It is very desirable indeed, to have many samples tested in this way, for if we had, say several hundred different experiments, it would be possible, by means of the method of least squares, to determine an approximate law for the influence of every impurity on the permeability. By inspecting the curves, we observe that the harder the steel, the poorer is the permeability. The samples 140

are in every case inferior to samples 10, which is simply due to the greater amount of impurities. Fig. 4 shows the best of the poorer quality (140) in comparison with the poorest of the better quality (10). Carbon alone has an enormous influence,

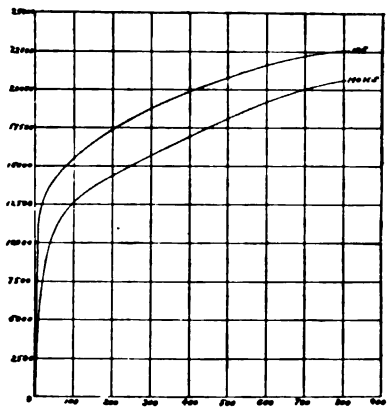

FIG. 4.

and it is even to be expected that there is a difference whether carbon exists free or in combination. It is also of interest to note that the harder the steel, the more definite will be the curve. Mild steel is more susceptible to magnetic influences, and any slight variation might therefore have considerable bearing. We might say that mild steel is in a kind of unstable equilibrium.

The temperature is another factor which must be observed in experimenting, but hardly while the iron is not more than warm; only at very high temperatures, around 400–600° Fahrenheit does the iron decrease in its magnetic properties, and at 760° it is not any better than air.

Rapidly magnetizing and demagnetizing has also an influencs on the iron, inasmuch as it heats the same and causes *hysteresis* losses. The word hysteresis means to "lag behind." If we discharge a magnet, that is, if we suddenly break the current flowing through the solenoid, we find that it takes a considerable length of time before the magnet is completely demagnetized; in fact, if we want the demagnetization to take place rapidly we must send a current through the solenoid in the opposite direction, thus using

up energy. The energy thus lost is called the hysteresis loss; it depends on the hardness of the iron or steel, on the thickness, on the shape of the magnet, on the chemical composition of the iron, and on the number of reversals of the magnetization.

The previous history has something to do with the permeability of any particular magnet; a piece of iron which has undergone frequent magnetization is somewhat easier magnetized, that is the lines of force are more easily induced and hence the permeability is higher. This, of course, is only a very small percentage of the permeability due to other factors.

The writer is aware of a possible criticism on his definitions of permeability, the theory of the lines of force is capable of a more rigid determination and deduction, but it requires a rather thorough introduction into the technical terms of electricity which at this place appeared inopportune. The principal object of this note is to call attention to the great value of thorough chemical analysis, of a perfect knowledge of the amount of temper a particular piece of iron or steel has undergone, and if any chemist or metallurgist can furnish such analyses, he will earn the gratitude of the electrical engineers, for he will then help to fortify him in one of the few branches of the subject which lack perfection.

LECTURE NOTES ON ROCKS.*

For Use without the Microscope.

By J. F. KEMP.

Chapter III. The Igneous Rocks, Continued. The Glasses. The Rocks Whose Chief Feldspar is Orthoclase. The Phonolites and Nepheline Syenites.

The Glasses.

	SiO_2	Al_2O_3	Fe_2O_3	FeO.	CaO.	MgO.	K_2O	Na_2O	Loss.	Sp. Gr
1.	79.49	11.60	0.33	0.49	1.64	0.09	1.52	4.04	0.68	
2.	76.20	13.17	0.34	0.73	0.42	0.19	4.46	4.31	0.33	2.352
3.	75.52	14.11	1.74	0.08	0.78	0.10	3.63	3.92	0.39	2.342
4.	74.70	13.72	1.01	0.62	0.78	0.14	4.02	3.90	0.62	2.345
5.	74.05	13.85	tr.	. .	0.90	0.07	4.31	4.60	2.20	
6.	74.05	12.97	2.73	. .	0.12	0.28	5.11	3.88	0.22	2.37
7.	74.01	12.95	. .	1.42	0.99	0.48	4.65	5.34	0.29	2.391
8.	72.87	12.05	1.75	. .	1.30	1.10	tr.	6.13	3.00	
9.	71.6	12.0	1.0	. .	1.1	0.2	4.3	2.5	7.4	
10.	71.56	13.10	0.66	0.28	0.74	0.14	4.06	3.77	5.52	
11.	65.13	15.73	2.24	1.86	3.62	1.42	3.96	2.93	2.43	
12.	60.5	19.1	4.2	0.3	0.6	0.2	3.5	10.6	. .	2.48
13.	54.28	14.83	14.73	. .	7.02	3.65	1.27	4.22	. .	2.704
14.	50.82	9.14	7.33	7.03	11.63	7.22	1.02	3.06	1.74	2.66
15.	45.73	20.15	12.46	. .	8.67	3.59	4.11	5.74	0.12	

1. Pumice, Cinder Cone, Calif., J. S. Diller, Bull. 79, U. S. G. S., p. 29. 2. Black Obsidian, Tewan Mtns., N. M., J. P. Iddings, 7th Ann. Rep. U. S. G. S., 219. 3. Red Obsidian, Yellowstone Park, J. P. Iddings, 7th Ann. Rep. U. S. G. S., 219, also FeS_2 0.11. 4. Black Obsidian, Yellowstone Park, J. P. Iddings, 7th Ann. Rep. U. S. G. S. 219, also FeS_2 0.40. 5. Scoriaceous Obsidian, Mono Lake, Cal., I. C. Russell, 8th Ann. Rep. U. S. G. S., 380. 6. Obsidian, Lipari Is. Abich. Vulk. Ersch. 62. 7. Obsidian from Andesite, Clear Lake, Cal., G. F. Becker, Mon. XIII., U. S. G. S. 104. 8. Perlite, Hungary, Kalkowsky, Elemente der Lith. p. 75. 9. Pitchstone, Meissen, Lemberg, Z. d. d. g. G. XXIX 508. 10. Pitchstone, Silver Cliff, Colo., W. Cross, Phil. Soc. Wash. XI. 420. 11. Andesitic perlite, Eureka, Nev. Hague. Mono. XX. U. S. G. S. 264. 12. Phonolite Obsidian, Teneriffe, Abich, Vulc. Ersch. 62. 13. Hyalomelane, Ostheim, Germany, Lemberg Z. d. d. g. G. XXXV. 570. 14. Pele's Hair, Hawaii, Cohen N. J. 1880, II. 41. 15. Tachylyte, Gethurms, Germany, Lemberg, See No. 13.

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Errata in November Number, p. 51, 17th line, appear, not appar; p. 52, 37th line, alumina, not alumnia; p. 54, 2d line, usually, not unusually; p. 56, 3d line, trachytes, not ilachytes.

Comments on the analyses. An examination of the table of analyses indicates that the magmas are high in SiO_2, and relatively low in all other bases except the alkalies. The high Na_2O of Number 12 is worthy of remark, being characteristic of a nepheline rock. The percentages under the column headed loss, which practically indicate the H_2O present are characteristic for different varieties. They are low in the case of obsidians, Nos. 2, 3, 4, 6, 7; unusually high in No. 5, described by Russell as scoriaceous obsidian; still higher in the perlites Nos. 8, 11; and reach a maximum in the pitchstones Nos. 9 and 10.

Basic glasses are seldom sufficiently free from included crystals as really to be separable from the prophyritic rocks. Frothy and cellular crusts, do however, appear on lava streams, and are known as scorias, and rare homogeneous glasses have been called tachylyte and hyalomelane.

Varieties. The chief glasses are obsidian, pumice, perlite and pitchstone. The name obsidian, is applied to homogeneous glasses with low percentages of water. The word is of classic and ancient origin and is now used with a prefixed name for all glasses, such as rhyolite-obsidian, basalt-obsidian, etc. Pumice is an excessively cellular glass, caused by expanding steam bubbles. Perlite is a glass broken into small onion-like, individual masses, by concentric cracks, from contractions in cooling. The concentric shelly masses lie in between intersecting series of larger straight cracks; the perlites have considerable water, usually 2–4%. The word is also written pearlstone, and was suggested by the fancied resemblance of the concentric shells to the familiar gem. Pitchstone is a homogeneous glass, like obsidian, but contains 5–10% of water. Pitchstones have often a more resinous appearance than obsidians, but there is no very essential difference apparent to the eye. The name was formerly used for glasses of earlier geological age than the obsidians. Obsidians are usually black or red, with translucent edges; pitchstones are mostly reds and greens, but thin slivers are practically colorless; all the glasses contain dusty embryonic crystals, gas pores, and sometimes skeleton crystals of larger growth, and even a few phenocrysts which are often arranged in flow lines and swirling eddies. Almost all large developments of the glasses show dense, stony or lithoidal layers, and streaks, that are due to the development of minute crystals of feldspar and quartz, which may be arranged in radiating rosettes,

called spherulites. The individual crystals are not often large enough to be seen with the unassisted eye. Expanded, bubble-like cavities are also met, with perhaps several concentric walls, on which at times are perched little well formed crystals. These cavities are called lithophysæ, *i. e.*, stone bubbles. Topaz, quartz, tridymite, feldspars, fayalite and garnet have been found in beautiful crystals in them. The lithophysæ are due to the influence and escape of mineralizers, and may reach a diameter of over an inch.

Relationships.—The glasses are all mere varieties of volcanic rocks, which a quick chill has prevented crystallizing. At the same time, it is only possible by field associations or by chemical analysis to refer them to their corresponding porphyritic types, although in the great majority of cases they are formed from rhyolitic magmas.

Geological Occurrence.—The glasses sometimes appear as independent sheets and dikes; more often they are on the surface of well crystallized lava-sheets or on the outer portions of dikes.

Alteration.—Glasses resist alteration notably well, but in the long run are subject to decay along cracks and exposed surfaces. They yield quartz, kaolin and fine, scaly muscovite. In instances they devitrify, as it is called, or break up into aggregates of quartz and feldspar in excessively minute crystals, so that we can only trace them back to the original glass, by the flow lines, spherulites, etc., that still remain. Such devitrified forms have been called by F. Bascom, apobsidian. Petrosilex is an older term applied to these and other similar rocks, and felsite has been also used.

Distribution.—The glasses are widespread in the West. Obsidian Cliff, in the Yellowstone Park, yields black, red and stony varieties, and has been made a type locality by the studies of J. P. Iddings. Silver Cliff, Colorado, has furnished some remarkable pitchstones, described by Whitman Cross. The extinct volcanoes of New Mexico, Utah, Montana and around Mono Lake, California, are well known localities. Alaska has supplied much from near Fort Wrangel, and in Mexico and Iceland are other prolific sources. Along the Atlantic Coast there are only the devitrified glasses of ancient (pre-Cambrian) volcanoes. These are well developed in New Brunswick, Maine, Massachusetts and Pennsylvania. Abroad the obsidian of the Lipari Islands is a famous one, and the perlites of Hungary supply the usual type specimens in our collections. The best known of all pitchstones are found at Meissen, near Dresden, in Saxony, and on the island of Arran, off the west coast of Scotland.

THE RHYOLITES.

	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	K_2O	Na_2O	Loss.	Sp. Gr.
1.	83.59	5.42	tr.	tr.	3.44	tr.	1.37	5.33	0.76	2.54
2.	78.95	10.22	3.23	. .	1.84	0.14	1.76	4.18		
3.	77.5	9.7	6.1	. .	. .	. .	5.8	0.3	0.4	
4.	75.20	12.96	0.37	0.27	0.29	0.12	8.38	2.02	0.58	
5.	73.91	15.29	. .	0.89	0.77	. .	4.79	3.62	1.19	
6.	73.07	11.78	2.30	. .	2.02	0.39	6.84	1.19	2.24	
7.	71.12	14.58	1.69	. .	1.50	0.15	6.01	3.26	0.95	
8.	70.92	13.24	3.54	0.66	1.42	0.23	4.25	4.28	0.57	
9.	70.74	14.68	0.69	0.58	4.12	0.28	2.59	2.29	2.09	2.68
10.	68.84	15.73	. .	3.11	3.58	0.90	3.59	2.89	1.50	2.4
11.	68.10	14.97	2.78	1.10	3.04	1.10	2.93	3.46	1.28	2.636
12.	67.20	14.95	5.19	. .	0.30	2.39	0.89	4.00	2.13	
13.	66.91	14.13	5.00	. .	2.35	0.95	5.40	3.86	1.42	
14.	66.60	16.69	2.06	0.93	1.40	1.15	5.23	2.46	1.70	2.43
15.	63.63	17.42	0.15	5.76	2.86	. .	5.54	4.52	0.15	

1. Soda-rhyolite, Berkeley, Cal. Palache. Bull. Geol. Dept. Univ. Calif. I. 61. 2. Rhyolite. Iceland, Bäckström, Contrib. to Icelandic Liparites. 3. Rhyolite, Wales, A. Harker, Bala Volc. Ser. 13. 4. Rhyolite, Silver Cliff, Colo. Cross. Colo. Sci. Soc. Dec. 5, 1887, 229. 5. Rhyolite, Pinto Peak, Eureka, Nev. A. Hague, Mono. XX., 264. 5. Rhyolite, McClelland Peak, Washoe Dist., Nev. F. A. Gooch, Bull. 17, U. S. G. S. 33, 6. Rhyolite, Island of Ponza, near Naples. Quoted by Kalkowsky, Elem. d. Lith., p. 75. 8. Rhyolite, Yellowstone Park. Idding's Origin Igneous Rocks, Tab. 1. 9. White Porphyry, Leadville, Cross, Mono. XII., U. S. G. S. 326. 10. Rhyolite, Lassen's Peak, Cal., Fortieth Paral. Survey I. 652. 11. Gray Porphyry, Leadville, Mono. XII. U. S. G. S. 332. 12. Quartz Porphyry, Flagstaff Hill, Colo., Palmer & Fulton, Colo. Sci. Soc. III., 356 13. Rhyolite, Hungary, v. Hauer, Verh. d. k. k. R. 1867, 118. 14. Quartz Porphyry, Upper Quinnesec Falls, Mich., G. H. Williams, Bull. 62, U. S. G. S. 120. 15. Quartz Porphyry, Waterville, N. H. Hawes, N. H. Geol. Surv. III. 178.

Comments on the Analyses.—The analyses illustrate the ranges of the various molecules. No. 1 is a very exceptional rock, alike in its high SiO_2 and CaO, and low Al_2O_3. The gradual increase of Al_2O_3 in all the others, with decrease of SiO_2, and in general the same relation as regards CaO are worthy of remark, as is the prevailingly low MgO. Sometimes K_2O, sometimes Na_2O, is in excess, and this brings out the reason why we spoke of orthoclase as the chief feldspar, not as the only one in the table, p. 55. The specific gravity is in general low.

Varieties.—Rhyolites proper are porphyritic rocks with phenocrysts of quartz, alkali-feldspar, usually orthoclase, of biotite, and less commonly hornblende and augite, in a ground-mass that is either glassy, or a finely crystalline aggregate of quartz and feldspar, or

both. The name rhyolite was coined from the Greek verb to flow, on account of the frequent flow structure. It is the name mostly used in America and England, whereas liparite (from the Lipari Islands) and quartz trachyte are employed in Europe. A variety with very little groundmass and an approximation to a granitoid texture is called nevadite, from the State of Nevada. In former years a distinction was made between the volcanic rocks of pre-Tertiary age and those of later date, and as against the later rhyolites the older were called quartz-porphyries, but the distinction has no serious foundations. At present some authors define quartz-porphyries as rocks corresponding to the rhyolites, but which have crystallized as intruded sheets, laccolites, sills and dikes. Nevertheless, while this distinction has some force, in any extensive collection of specimens no very notable difference can be detected in the hand specimens even by a very practiced observer. Rhyolites from the inner parts of thick surface flows, and from their branching dikes, can be found, especially when alteration has advanced somewhat, to match all quartz-porphyries, but as a general rule quartz-porphyries are denser and less cellular than rhyolites. The meaning of both words should be well understood on account of their presence in the literature. Certain *microscopic* structures due to the interpenetration of quartz and feldspar are also seen in the quartz porphyries (*i. e.*, intruded sheets), that are seldom met in surface flows, but these have no value in ordinary study. An old and very useful term is *felsite*, which has been applied especially to acidic lavas of ancient geological date, that lack phenocrysts, wholly or largely. Whether they correspond to rhyolites or to less acidic magmas, such as trachytes, is not always apparent without chemical analyses. Felsites are dense, usually green, red or gray rocks, which only indicate to the eye that they are very finely crystalline. They really consist almost entirely of minute quartz and feldspar crystals, practically a groundmass without phenocrysts, but it is not always apparent whether they represent original crystallizations from fusion, or devitrified obsidians (apobsidians) or recrystallized tuffs, all of which have been demonstrated in one place or another. Those certainly derived from rhyolites have been called aporhyolites.

Rhyolites high in soda are called soda-rhyolites, or pantellerites, (see analyses 1 and 2). Ancient rhyolites (quartz-porphyries, felsites) rich in soda have been called quartz-keratophyr (see analysis

12), the distribution being made because the feldspar present must be anorthoclase as against true orthoclase. As the true porphyritic texture graduates into the granitoid, we have intermediate rocks called granite porphyries, of which mention is made under granites.

Mineralogical composition.—The principal minerals present of recognizable size are quartz, in rounded or doubly terminated (*i. e.*, dihexagonal) pyramids with practically no prism faces; and feldspar, including orthoclase, less often anorthoclase, and a soda-lime plagioclase belonging in the series from albite to oligoclase. Biotite is much the commonest dark silicate, although hornblende, and less often augite, are occasional. It is important to appreciate that the dark silicates are vastly inferior in quantity to the light ones. As regards the groundmass, by the unaided eye, we can only determine that it is glassy (called also hyaline), or finely crystalline, that is, felsitic, or coarsely crystalline. Vesicular groundmasses are met in surface flows, not in intruded masses. Lithophysæ also occur in rhyolites as well as in volcanic glasses.

Relationships.—Rhyolites pass by insensible gradations into glasses on one side, trachytes on another, granites on a third and dacites on a fourth. Without the microscope rhyolites can only be identified with certainty by recognizing the quartz, and may then be confused with dacites. The striated feldspar of the latter is our chief means of distinction between the two.

Alteration.—Ordinary decay leads to the formation of clays and kaolin. In metamorphic alterations the rhyolites pass into very finely crystalline aggregates of quartz and feldspar, and then it is difficult to decide what minerals are original and what secondary, and whether the original rock was a massive one or a tuff. Shearing stresses develop schistose structures, and when decay is further superadded sericite schists may result that are extremely difficult geological problems.

Distribution.—Rhyolites are common in the Western States, being well known in the Black Hills; the Yellowstone Park; in Colorado, where Chalk Mountain, near Leadville, is a type locality for Nevadite; in Nevada, both near Eureka and near the Comstock lode, and in California. The so-called quartz-porphyries have been also met in many Western districts, but are of especial importance at Leadville, where they are intimately associated with the ores. The ancient rhyolites (quartz-porphyries) have also an

important development on Lake Superior. The greater part of the boulders in the Calumet copper conglomerate consist of them, and Lighthouse Point, near Marquette, furnishes an outcrop. Along the Atlantic Coast the pre-Cambrian rhyolites (felsites) are present in the same localities as those cited for volcanic glasses. Recent rhyolites are in vast quantity in Iceland. Many are known in Europe, but the enormous development in Hungary is especially worthy of note. The sheets of rhyolite on the Lipari Islands, between Naples and Sicily, suggested the name Liparite. In almost all volcanic districts they are liable to occur. In the Tyrolese Alps quartz-porphyries are of great extent, and in Scandinavia and in Cornwall, they form important dikes, familiar to all students of the subject.

RHYOLITE TUFFS.—These are the fragmental ejectamenta from explosive eruptions and often afford very extensive strata of rock. Although loose at the time of falling, they become consolidated to fairly firm rock in the course of time, and may be sorted and redeposited in water so as to share the nature of a true sediment. Fragments of volcanic glass and of all the component crystals of rhyolite make them up, while larger fragments of rock and volcanic bombs are at times intermingled. Tuffs of ancient geological date become metamorphosed and recrystallized, so as to afford products not to be easily distinguished from compact felsites.

Rhyolite tuffs are abundant along the eastern foothills of the Front Range of Colorado, and are extensively quarried for a rather soft building stone.

THE TRACHYTES.

	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	K_2O	Na_2O	Loss.	Sp. Gr.
1.	66.03	18.49	2.18	0.22	0.96	0.39	5.86	5.22	0.85	2.59
2.	65.07	16.13	5.17	. .	2.74	0.67	4.44	4.77	0.70	
3.	62.28	19.17	3.39	. .	1.44	. .	5.93	5.37	2.33	2.65
4.	62.17	18.58	2.15	1.05	1.57	0.73	3.88	7.56	1.70	
5	58.70	19.26	3.37	0.58	1.41	0.76	4.53	8.55	2.64	
6.	57.7	17.9	4.4	3.9	3.7	1.8	7.7	3.8	0.1	2.61

1. Trachyte, Game Ridge, Custer Co., Col., Cross, Proc. Col. Sci. Soc., 1887, 237. 2. Oligoclase-trachyte Drachenfels on Rhine, Rammelsberg, Z. d. d. g. G. XI., 440, 1859. 3. So-called Bostonite dike, Lake Champlain, J. F. Kemp, Bull. 107, U. S. G. S., 20. 4–5. Acmite-trachyte, Crazy Mountains, Mont., Wolff and Tarr, Bull. Mus. Comp. Zoöl. XVI., 232. 6. Trachyte, Arso Flow, Ischia near Naples. Abich, Isola d'Ischia, 38. Silica determinations on eleven trachytes from the Black Hills afforded J. H. Caswell values from 65.46 to 52.02.

Comments on the Analyses.—The decrease in silica and the increase in alumina and the alkalies as against the rhyolites is noteworthy. The alkalies in particular are high, with sometimes potash, sometimes soda, in excess. The latter marks the passage to the phonolites.

Varieties. Trachyte is a name derived from the Greek word for rough, and refers to the rough surfaces of those first studied. The name was of much wider application in earlier years than today and was used for both rhyolites and trachytes. If soda is high, the soda pyroxene acmite may form and give name to the rock as in analyses 4 and 5. Pantellerite is another name for those that are rich in soda and that have anorthoclase feldspar. The widely and loosely used name porphyry is applied to pre-Tertiary trachytes, and to intruded sheets and dikes. Bostonite has been employed for such dikes and to both dikes and sheets when rich in soda, the name keratophyre has been given. Many felsites also belong here, but for all these the remarks made under rhyolites apply. The distinctions are only of importance in close microscopical work and when the idea of the geological relations is involved in the definition, but both porphyry and felsite are useful current terms. Porphyry, it should be remarked, is used in mining circles in the West, for almost every rock that occurs in dikes or sheets.

Mineralogical composition. The principal minerals of recognizable size are alkali-feldspar, chiefly orthoclase of the variety called sanidine, a little acidic plagioclase; more or less biotite, hornblende and pyroxene in this general order. The light-colored silicates are in notable excess over the dark ones. The groundmass is glassy or finely, or (rarely) coarsely crystalline.

Alteration. The alteration is practically the same as that described under rhyolites.

Relationships. With increase of soda, trachytes pass into phonolites, to which indeed they are closely related. With the development of granitoid structure they (including porphyries) pass into syenites. They are easily confused with some andesites unless the eye can detect the striated feldspar, but, as noted in the next paragraph, they are comparatively rare rocks.

Distribution.—True volcanic trachytes are extremely rare in this country, for many of the earlier cited localities, as, for instance, some of those in the Reports of the Fortieth Parallel Survey, have

peculiar leucite rock, with abundant scales of biotite, gives the name to the Leucite Hills, two or three miles north of Point of Rocks, Wyo. Leucite tinguaites occur near Magnet Cave, Ark., in the Highwood Mountains, Mont., and near Rio Janeiro, Brazil.

Tuffs are known abroad but not in this country, and exhibit few features calling for special mention.

THE GRANITES.

	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	K_2O	Na_2O	Loss.	Sp. Gr.
1.	73.76	13.43	1.16		1.42	0.75	5.22	4.01	0.42	2.63
2.	73.70	14.44	0.43	1.49	1.08	tr.	4.43	4.20	0.40	2.69
3.	73.05	14.53	2.96	. .	2.06	tr.	5.39	1.73	0.29	
4.	72.4	13.04	0.68	2.47	0.66	0.58	4.97	3.44	1.21	
5.	72.26	15.59	1.16	2.18	1.13	0.06	5.58	3.85	0.47	2.65
6.	71.78	14.75	. .	1.94	2.36	0.71	4.89	3.12	0.52	
7.	71.64	15.66	2.34	. .	2.70	tr.	5.6	1.58	0.48	
8.	69.46	17.50	2.30	. .	2.57	0.30	4.07	2.93	0.82	2.687
9.	69.28	17.44	2.30	. .	2.30	0.27	2.76	3.64	. .	
10.	68.68	16.28	0.66	2.55	2.24	0.81	4.07	2.88	0.85	
11.	66.84	18.32	2.27	0.20	3.31	0.81	2.80	5.14	0.46	
12.	66.68	14.93	1.58	3.23	4.89	2.19	2.05	2.65	1.25	
13.	66.40	17.13	. .	3.77	4.05	0.94	2.08	4.49	1.03	

1. Biotite granite, Green's Landing, Me., E. F. Hicks. Privately communicated. 2. Granitite, Peterhead, Scotland, Phillips, Q. J. G. S., XXXVI., 1880, 13. 3. Red Granitite, Westerly, R. I. F.W. Love, for J. F. K , unpublished. 4. Soda Granite, Pigeon Pt., Minn., W. S. Bayley, A. J. S., iii., XXXVII., 59. 5. Albany granite, N. H. Hornblende granite, G. W. Hawes, A. J. S., iii., XXI., 25. 6. Hornblende granite with biotite, Cottonwood Cañon, Utah, T. M. Drown, 40th Parallel Surv., I., 110. 7. Gray granitite, Westerly. R. I., see No. 3. 8. Typical granite, Chester, Mass., L. M. Dennis, for J. F. K., N. Y. Acad. Sci., XI., 129. 9. Biotite granite, Raleigh, N. C., G. P. Merrill, Stones for building and decoration, 418. 10. Biotite granite with hornblende, Wood Cone, Eureka Dist., Nev., A. D. Hague, Mono., XX., U. S. G. S., 228. 11. Augite-soda granite, Kekequabic Lake, Minn., U. S. Grant, Amer. Geol., June, 1893, 385. 12. Granitite, Rowlandville, Md., Jour. Cin. Soc. Nat. Hist., 1894, p. 32. 13. Biotite granite with hornblende, El Capitan, Yosemite, see No. 6.

Comments on the Analyses.—These analyses illustrate the general range of SiO_2, but granites are known outside of both limits. As SiO_2 decreases the bases increase, and soda tends to exceed potash, marking the passage to the diorites. Those high in Na_2O, like No. 12, are often called soda-granites. They are analogous to the keratophyres, soda-rhyolites and pantellerites, earlier referred to. The whole table is a close parallel to that of the rhyolites. The analyses are selected, so far as possible, to represent prominent building stones.

Mineralogical Composition and Varieties.—Granites are, par excellence, granitoid rocks consisting of orthoclase, sometimes microcline, some acid plagioclase, quartz, and in the typical variety both biotite and muscovite. Magnetite, apatite and zircon are always present, though small, and garnet is not at all unusual. Biotite is much the commoner of the micas, and when present alone the rock is sometimes called granitite. Granites with muscovite alone are especially found in the form of dikes. They are called aplite. Hornblende is also frequently met, either with biotite or by itself, giving then hornblende-granite. In former years this aggregate was called syenite, but the modern usage is different. Augite in granites is uncommon, and marks a passage to the gabbros. All forms of dark silicates and mica may fail, and then we have the so-called binary granites. Some Missouri granites are of this character.

Especially in regions of granite intrusions and of extensive metamorphism, veins or dikes—it is an open question which is the more correct term—are met formed of very coarsely crystalline aggregates of the same minerals that constitute granite. These are called pegmatite and in them is the home of graphic granite, the curious intergrowth of quartz and feldspar, such that a cross fracture of the blades of quartz suggests cuneiform characters. Garnet, tourmaline, beryl and minerals involving the rare earths, are often found in pegmatites, and they supply the feldspar and mica of commerce. The outcrops may be two hundred feet broad or more, and again the same aggregates are found as small lenses or "Augen" in metamorphic rocks. In regard to the larger veins or dikes it seems improbable that true igneous fusion could have afforded such coarsely crystalline aggregates, and so we are forced to assume such abundance of steam and other vapors, *i. e.*, mineralizers, as to almost, if not quite, imply solution.

Undoubted dikes of the composition of granite are also known, that have no such unusual size of minerals, but that tend to develop a porphyritic texture from the presence of feldspars larger than the general run of the component minerals. These are called granite-porphyries, and they pass by insensible gradations, through finer and finer groundmasses, into typical quartz-porphyries. The phenocrysts of granite-porphyries may also fail and the groundmasses become finer and finer, passing through a stage called micro-granite into the felsites.

The outer portions of granite masses are often subjected to the action of escaping vapors, containing boracic and hydrofluoric acids (fumarole action). These develop tourmaline in quantity and often fluorite, and in rare instances cassiterite. In a famous case near Luxullian, in Cornwall, the feldspar has become changed to an aggregate of tourmaline needles and quartz, and the rock is called luxullianite. Tourmaline granite is, however, also known in which tourmaline plays the role of mica or hornblende, as at Predazzo, in the Tyrol. Fumarole action may change the borders of granites to a mass of quartz and a lithia mica, affording the rock that is called greisen and that is a familiar gangue for tin ores.

Granites are commonly gray, bluish or reddish in color. The feldspar is mainly responsible for this, as quartz is colorless and transparent and biotite and hornblende are not specially abundant; but unusual richness in the last named silicates tends to darken the shade. These latter are very frequently segregated into the black bunches that are noticeable in many building stones. They may be spheroidal in their alignment, affording so-called orbicular granite.

Relationships.—The passage of granites, through granite-porphyries and micro-granites, into quartz-porphyries and felsites, has been remarked. Sometimes along the border of an intrusion, this can be traced inch by inch to a place where the porphyritic texture is due to a quick chill. Mt. Willard, in the Crawford Notch of the White Mountains is a classic locality of this phenomenon. It was described in 1881 by Geo. W. Hawes (see analysis 6), and will be referred to again under the rocks of contact metamorphism. The close relationship of the granitoid rhyolites or nevadites with granite need only be referred to. As quartz decreases, syenites result by insensible gradations, and as hornblende or biotite and plagioclase increase, the same passage is made to diorites. Intermediate varieties, which are very common, are often called granite-diorites or grano-diorites. Transitional passages to gabbro, from increase of augite and plagioclase, are also well recognized.

Geological Occurrence.—Granites in their most typical development constitute great irregular masses that have solidified at depths; such are called bathylites, and it is generally believed that before consolidating they have often fused their way upward by melting into themselves overlying rock. Granites also appear as irregular or rounded outcrops in the midst of other rocks (bosses or knobs) and as dikes. There is no reason why granites should

not form at all geological ages, but those open to our observation are mostly Archean and Paleozoic because, being deep-seated rocks, only the older ones have been exposed by erosion. The relations of pegmatites to veins have been earlier set forth. Granites tend to break apart by jointing planes in rectangular blocks, a property that much facilitates their quarrying. They also have lines of weakness admitting of their further division into blocks. The development of these is more or less characteristic of each particular locality.

Uses.—Granites are much more extensively employed for structural purposes than any other igneous rock, and indeed in the trade any crystalline rock consisting of silicates is called granite. They are in general the strongest of the common building stones. Crushing resistances range from 10,000 to 25,000 pounds per square inch in a 2-inch cube. The important points are homogeneity of texture, good, rectangular cleavages in the quarry, adaptability to tool treatment, and pleasing color.

Alteration, Metamorphism.—In ordinary decay granites suffer first by the oxidation of the protoxide of iron in the ferromagnesian silicates (biotite, hornblende), and the formation of chlorite and other secondary minerals. The feldspars also kaolinize, and the rock thus becomes hydrated. Pyrite, if present, is an active agent in decay. Yet the chemical changes involved, except hydration, seem to be comparatively slight even in the change from granite to soil. G. P. Merrill gives the following analyses of unaltered and altered biotite granite from the vicinity of Washington, D. C. (Bull. Geol. Soc. Amer. VI., 323).

	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	K_2O	Na_2O	Ignition.
1.	69.33	14.33	. .	3.60	3.21	2.44	2.67	2.70	1.22
2.	66.82	15.62	1.88	1.69	3.13	2.76	2.04	2.58	3.27
3.	65.69	15.23	4.39		2.63	2.64	2.00	2.12	4.70

No. 1 is fresh and undecomposed rock; No. 2, decomposed but still moderately firm rock; No. 3, soil. It is evident at once that there has been considerable hydration, and that a notable decrease in the alkalies has occurred, each being affected about equally in the end, although K_2O yields first; MgO has relatively increased; CaO has suffered loss; the FeO is all oxidized, the Al_2O_3 has relatively increased and the SiO_2 decreased. While appreciating these chemical changes, Dr. Merrill still emphasizes the much greater superiority of the physical alteration and attributes this to swelling

from hydration. Other interesting data are given in the citation. Similar sets of parallel analyses have been made abroad with analogous results in the case of the chemical rearrangements.

Under dynamic stress granites are more or less crushed and have their minerals drawn out into laminations from shearing strains so that they readily assume gneissoid structures. Beyond question many gneisses have resulted in this way, and in the geology of some districts, as, for instance, the Front Range of Colorado, we employ the term granite-gneiss. The structures were, doubtless, induced while the granite was deeply buried and subjected to pressure while closely confined, so that the yielding came in a gradual flow.

Distribution.—Granites are abundant along the Atlantic coast, and are near tidewater from Canada to Virginia. Further south they lie back of the Coastal Plain. They are chiefly biotite granite and are extensively quarried. A famous hornblende granite is obtained at Quincy, Mass., that was formerly called syenite. In the old crystalline areas of Michigan, Wisconsin and Minnesota they are common. Missouri has many in the region of the porphyries, already cited. In the West, the Black Hills, the Rocky Mountains, the Wasatch and the Sierras are abundantly supplied. They are equally common in Europe and elsewhere the world over.

THE SYENITES.

	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	K_2O	Na_2O	Loss	Sp. Gr.
1.	60.03	20.76	4.01	0.75	2.62	0.80	5.48	5.96	0.59	
2.	59.83	16.85	.	7.01	4.43	2.61	6.57	2.44	1.29	2.73
3.	59.78	16.86	3.08	3.72	2.96	0.69	5.01	5.39	1.58	2.689
4.	59.37	17.92	6.77	2.02	4.16	1.83	6.68	1.24	0.38	2.71
5.	56.45	20.08	1.31	4.39	2.14	0.63	7.13	5.61	1.77	
6.	46.11	14.75	2.20	4.51	7.82	5.73	3.84	1.29	1.59	2.904
7.	46.73	10.05	3.53	8.20	13.22	9.68	3.76	1.81	1.24	

1. Fourche Mtn., near Little Rock, Ark., J. F. Williams; Igneous Rocks of Ark., 88. 2. Plauen, near Dresden, F. Zirkel, Pogg. Ann., CXXII., 622. 3. Custer Co., Colo. Cross, Proc. Colo. Sci. Soc., 1887, 240. 4. Biella, Piedmont,Cossa., Turin Acad. ii., XVIII., 28. 5. Sodalite-Syenite Highwood Mtns., Mont. W. Lindgren, A. J. S., Apr., 1893, 296. 6. Minette, Rhode Island, badly decomposed, contained CO_2 7.32, Pirsson, A. J. S.. Nov., 93, 375. 7. Shonkinite, Highwood Mtns., Mont., Pirsson, Bull. Geol. Soc. Amer. VI. 414.

Comments on the Analyses. The syenites mark a decrease in SiO_2 from the granites and a general increase in all the bases The

high percentage of alkalies is especially worthy of remark, and the notably large amounts of soda, showing the passage to the nepheline syenites. The parallelism with the trachytes is close. The last two analyses exhibit excessively basic extremes, whose theoretical significance is commented on in the next paragraph.

Mineralogical Composition, Varieties.—The name syenite was suggested by Syene, now Assuan, an Egyptian locality where a hornblende granite was formerly obtained for obelisks, and if its local significance were perpetuated, syenite as formerly should be applied to this rock. But Werner used it in the last century for the well-known typical rock from the Plauenschen Grund (see Analysis 2), near Dresden, that contains almost no quartz, and of recent years this has been its correct use. Typical syenites have orthoclase and hornblende; those with biotite are called mica-syenites. Some plagioclase is always present and magnetite, apatite and zircon are invariable. Mica syenites in dikes, basic and of dark color have been called minette. Orthoclase and augite afford augite-syenite. An excessively basic one (Analysis 7), from the Highwood mountains, Mont., has recently been described by Pirsson under the name Shonkinite. It is of great theoretical importance, as it shows that orthoclase is not limited to acidic rocks, but may be the prevailing feldspar in very basic ones. Still more recently J. P. Iddings has noted others of similar character from the region of the Yellowstone Park. (Jour. of Geology, December, 1895, 935.) Basic nepheline-syenites have been earlier known. Still the table on page 55 expresses the general truth, the exceptions being excessively rare rocks so far as yet known. Syenites are themselves rare rocks. With high soda, the mineral sodalite develops and yields sodalite syenites which are passage forms to nepheline syenites.

Relationships.—Syenites are most closely allied with nepheline-syenites, into which with increase of soda they readily pass. They also with increasing plagioclase shade into diorites and the augite-syenites are closely akin to gabbros.

Geological Occurrence.—Syenites form irregular masses and dikes, precisely as do granites.

Alteration.—There is little to be said that was not covered under granite. The rarity of syenite makes it a much less serious factor. In metamorphism they pass into gneisses.

Distribution—Syenites occur in the great igneous complex of the

White Mountains. They form large knobs and dikes near Little Rock, Ark., and a dike is known in Custer county, Colo. The only American minette yet discovered, is a dike on Conanicut Island, R. I., described by Pirsson (see Analysis 7). Abroad, syenites are better known. The Plauenscher Grund, near Dresden, Biella in the Piedmont, and the vicinity of Christiania, Norway, are the best known. Minettes are especially famous in connection with the mining district about Freiberg, Saxony, and in the Vosges mountains.

THE NEPHELINE SYENITES.

	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	K_2O	Na_2O	Loss.	Sp. Gr.
1.	60.39	22.51	0.42	2.26	0.32	0.13	4.77	8.44	0.57	
2.	59.70	18.85	4.85	. .	1.34	0.68	5.97	6.29	1.88	
3.	59.01	18.18	1.63	3.65	2.40	1.05	5.34	7.03	0.50	
4.	56.30	24.14	1.99	. .	0.69	0.13	6.79	9.28	1.58	
5.	54.20	21.74	0.46	2.36	1.95	0.52	6.97	8.69		
6.	52.75	22.55	3.65	. .	1.85	0.15	7.05	8.10	3.60	
7.	51.90	22.54	4.03	3.15	3.11	1.97	4.72	8.18	0.22	
8.	50.96	19.67	7.76	. .	4.38	0.36	6.77	7.67	1.38	
9.	50.36	19.34	6.94	. .	3.43	. .	7.17	7.64	3.51	
10.	41.37	16.25	16.93	. .	12.35	4.57	3.98	4.18	0.45	

1. So-called Nepheline Syenite, or Litchfieldite, Litchfield, Me., Bayley, G. S. A., III., 241. 2. Neph. Syenite, Fourche Mountains, Ark., J. F. Williams, Igneous Rocks of Ark., 88. 3. Neph. Syenite, Red Mountains, N. H., Bayley, G. S. A., III., 250. 4. Ditroite, Hungary, Fellner, Nenes, Jahrb., 1868, 83. 5. Foyaite, Portugal, Jannasch. Neues Jahrb., II., 11. 6. Neph. Syenite, Sao Paulo, Brazil, Machado. Tsch. Mitt., IX., 1888, 334. 7. Laurdalite variety of Nepheline-Syenite. Lund, Norway, Brögger, Syenit-pegmatit-gänge, 33. 8. Leucite-syenite, Arkansas, J. F. Williams. Igneous Rocks of Ark., 276. 9. Nepheline Syenite, Beemerville, N. J., F. W. Love for J. F. K., N. Y. Acad. Sci., XI., 66. 10. Basic Nepheline Syenite, Beemerville, N. J., J. F. K., N. Y. Acad. Sci., XI., 86.

Comments on the Analyses.—A considerable range is shown in the SiO_2, some analyses going below the usual percentages for syenites and the last analysis being abnormal. In general the amounts of alkalies are extremely high, with Na_2O in excess, in which respect the phonolites are paralleled.

Mineralogical Composition and Varieties.—The minerals of nepheline syenite are in general the same as those of syenite proper, with the addition of nepheline, often sodalite, and several characteristic ones into which the rare earths often enter as bases. Zircon is widespread and often large enough to afford fine crystals. For this reason the rocks were named zircon-syenite many years

ago. The nepheline is often called eleolite (or elæolite), from the former custom of speaking of this mineral in pre-Tertiary rocks as elæolite and in later ones as nepheline, just as we have had orthoclase and sanidine, but the custom is gradually falling into disuse. Attempts have been made to give different names according to the dark silicate; for instance, those with hornblende were called foyaite, from Foya, a Portuguese locality; those with biotite, miascite from Miask, in the Urals. But both these minerals so often appear together or with pyroxene that the practice is not generally observed. Ditroite is a variety rich in blue sodalite. The Litchfield, Me., rock has been shown by Bayley to have as its feldspar almost exclusively albite, and he, therefore, has called it litchfieldite. The texture of nepheline syenites varies very much. At times it is very coarsely granitoid, and again it is what is called trachytic, *i. e.*, with little rods of feldspar, more or less in flow lines, like a trachyte and marking a passage to the phonolites. Types have been based on these characters. Where at all finely crystalline, the determination of nepheline-syenites, as against true syenites, is a matter for the microscope. Nepheline-syenites are comparatively rare rocks. Corresponding rocks with leucite are as yet only known from Arkansas and Montana.

Relationships.—As already remarked, the nepheline-syenites are closely related to the true syenites, and to the phonolites. With certain basic plagioclase rocks with nepheline, called theralites, they are also of near kinship.

Geological Occurrence, Alteration.—The nepheline-syenites are specially prone to appear as dikes, often on a very large scale. Their alteration affords no special features, as distinguished from the syenites or granites, except as regards the secondary minerals from the nepheline. Natrolite, muscovite and kaolin are all known in this relation and the last two have been called liebenerite and gieseckite. Cancrinite also results from the alteration of nepheline. The rarity of the nepheline-syenites has prevented their playing an important role among metamorphosed rocks.

Distribution.—Nepheline-syenites are known in this country at Montreal and Dungannon, Ont.; Litchfield, Me.; Red Hill, N. H.; Salem, Mass.; Beemerville, N. J., where a superb dike is exposed; and near Little Rock, Ark., where the area is extensive. Very interesting ones occur near Rio Janeiro, and in the State of Sao Paulo, Brazil. Abroad the Portuguese locality, in the Monchique

Mountains; the one at Ditro, in Hungary, and the wonderful dikes near Christiania, in Norway, so prolific in rare minerals, are of especial interest.

CHAPTER IV. THE IGNEOUS ROCKS, CONTINUED. THE DACITES, ANDESITES AND THE ROCKS OF THE BASALT GROUP.

THE DACITES AND ANDESITES.

THE DACITES.

	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	Na_2O	K_2O	Loss.	Sp. Gr.
1.	69.96	15.79	2.50	. .	1.73	0.64	3.80	4.12	1.53	
2.	69.36	16.23	0.88	1.53	3.17	1.34	4.06	3.02	0.45	
3.	67.49	16.18	1.30	1.22	2.68	1.34	4.37	2.40	2.69	
4.	67.2	17.0	3.5	1.2	4.5	1.5	3.7	1.6	0.9	
5.	67.03	16.27	. .	3.97	3.42	1.19	2.71	3.50	1.56	
6.	66.03	14.57	2.57	1.19	3.38	1.89	3.71	2.70	2.07	
7.	63.36	16.35	2.12	3.05	4.79	3.28	3.58	2.92	0.99	

THE ANDESITES.

8.	67.83	15.02	. .	5.16	3.07	0.29	2.40	3.20	1.11	
9.	65.50	14.94	1.72	2.27	2.33	2.97	5.46	2.76	1.37	
10.	63.49	18.40	2.44	1.09	2.30	.66	5.70	4.62	1.04	
11.	62.94	18.14	. .	3.82	6.28	3.06	3.83	1.22	0.60	
12.	61.62	16.86	. .	6.61	6.57	2.07	3.93	1.66	. .	
13.	61.58	16.34	. .	6.42	5.13	2.85	2.69	3.65	0.64	
14.	59.48	16.37	3.21	3.17	4.88	3.29	3.30	2.81	2.02	
15.	56.19	16.12	4.92	4.43	6.99	4.60	2.96	2.37	1.03	
16.	56.91	18.18	4.65	3.61	7.11	3.49	4.02	1.61	0.36	

1. McClelland Peak, near Comstock Lode, Nev., F. A. Gooch., Bull. 17, U. S. G. S., 33. 2. Lassen's Peak, California, Hague and Iddings, A. J. S., Sept., 1883, 232. 3. Sepulchre Mountain, Yellowstone Park, J. P. Iddings, Phil. Soc. Wash., XI., 210. 4. Nagy-Sebes, Hungary, Doelter Tscher. Min. Petr. Mitt., 1873, 93. 5. Eureka Dist., Nev. A. Hague Mono., XX., U. S. G. S., 264. 6–7. Colombia, S. America. From Küch's Petrographie of Colombian Volcanoes, quoted in Jour. Geol., I., 171. 8. Hb.-mica-andesite, Eureka Dist., Nev., Mono., XX., U. S. G. S., 264. 9. Hb.-mica-and., Sepulchre Mountains, Yellowstone Park, J. P. Iddings, Phil. Soc. Wash., XI., 210. Compare No. 3. 10. Mica-and. Rosita Hills, Colo., W. Cross, Colo. Sci. Soc., 1887, 250. 11. Lassen's Peak, Calif., Hague and Iddings, A. J. S., Sept., 1883, 225. 12. Mt. Rainier. See last reference. 13. Pyroxene-andesite, Eureka Dist., Nev., Mono., XX. U. S. G. S., 264. Compare No. 5. 14. Hypersthene-andesite, near Red Bluff, Mont., G. P. Merrill, Proc. U. S. Nat'l Museum, XVII., 651. 15. Hypersthene-andesite, Buffalo Peak, Colo., W. Cross, Bull I., U. S. G. S., 26. 16. Colombia, S. America. See Nos. 6 and 7.

Comments on the Analyses. It appears at once from the analyses, that the dacites are high in silica, in which they equal the lower

ranges of rhyolites. As compared with the latter, soda is prevailingly in excess of potash, and as a rule the other bases run higher. The andesites lap over the lower limits of the dacites and have much the same range in silica as the trachytes. All the bases reach notable percentages, but the alkalies recede as the others increase.

Mineralogical Composition, Varieties. The name dacite is derived from the old Roman province of Dacia, now a part of modern Hungary The name andesite was suggested by the abundance of these lavas in the Andes Mtns. Quartz occurs usually in abundant crystals in the dacites, causing them to closely resemble the rhyolites. The distinction, when it can be made, and this is not always without the microscope, depends on the prevalence of striated feldspars. The prevailing dark silicate is biotite, as is usually the case with an acidic rock. Hornblende and augite are rarer. Magnetite and the small accessory minerals, apatite, zircon, etc., are generally present. In the acidic andesites, biotite is also commonest; hornblende and then pyroxene favor those of decreasing silica. Andesites with biotite are usually called mica-andesites. Andesite when used alone implies hornblende-andesite. Prevailing augite is indicated by the name augite-andesite. If magnesia is in considerable amount hypersthene may result and afford hypersthene-andesite, a frequent rock in the West, but for all one can usually say from ordinary examination, the rocks may be augite-andesite, or even hornblende-andesite. Andesites strongly resemble trachytes, but it is to be appreciated that trachytes are comparatively rare rocks, while andesites are among our commonest lavas, and along the west coast of North and South America are the prevailing volcanic rock. The dark silicates are also increasingly abundant in the andesites. They pass insensibly into diorites, by the development of granitoid texture. The older andesitic lavas have been called porphyrites, on the analogy of porphyry, and then mica, or hornblende or augite is prefixed. Others use porphyrite for intruded sheets and dikes; and others still for varieties, with a groundmass of medium coarseness, restricting thus andesite to the finely crystalline or glassy varieties of groundmass and diorite to the coarse, granitoid rocks. These distinctions belong, however, to the refinements of the subject.

On analogy with the name trachyte, which was formerly applied in the field to all these more or less rough and cellular lavas,

but which is now, by universal consent, restricted to the orthoclase rocks, G. F. Becker has suggested that "asperite" be used for those with plagioclase, basing it on the Latin word for rough. With general acceptance it ought to prove a very useful term, because the observer is often in doubt whether a rock is dacite or andesite, and if the latter, to which group it belongs. Propylite is a name still more or less current in the West. It was created for a series of rather coarsely crystalline or granitoid andesites, that are of pre-Tertiary age, and that often have the dark silicates altered to secondary minerals. The name means "before the gates," and the significance was that coming just before the geological time of the true volcanics, yet resembling them, they deserved this distinction. It is now obsolete and reasons for its special existence were long ago exploded, but having been employed on the Comstock lode, it has passed into western usage. There is no special and necessary geological age for any igneous rock.

Alteration, Metamorphism.—The andesites in decay afford kaolinized material and mixtures of this with chloritic products that are very difficult to identify. Thus the now famous andesitic breccia at Cripple Creek, Colo., can rarely be shown to the eye to be other than a white, kaolinized mass, and decomposed outcrops of massive flows are no less unsatisfactory. Where metamorphic processes affect older flows, felsitic and silicified forms, result similar to those mentioned under rhyolites. The tracing of the history of the rock is then a matter for the microscope and chemical analysis, when indeed it can be done.

Tuffs.—Andesitic tuffs and breccias (*i. e.*, aggregates of angular, volcanic ejectments coarser than tuffs) are rather common in the western volcanic districts. With ordinary observation they can only be identified by finding fragments large and fresh enough to indicate the original. Such have proved of great economic importance at Cripple Creek, Colorado.

Distribution.—Andesites are very wide spread in the West. The vast laccolites that form many of the peaks in Colorado are intruded andesites (porphyrites) of a rather acidic type, frequently with some orthoclase. In the Yellowstone Park they are important. In Nevada, as at Eureka and the Comstock lode, they have proved of great geological interest, and especially near the latter, with its many miles of drifts, shafts and tunnels, very important data for the study of rock masses have been afforded. The old cones along

the Pacific, Mt. Hood, Mt. Shasta, Mt. Rainier and others are chiefly andesite. The products of Mexican and South American volcanoes are also of this type, and indeed along the whole Pacific border the recent lavas have many features in common. Abroad andesites are seldom lacking in great volcanic districts.

THE BASALTS, INCLUDING DIABASE.

Basalts.	SiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	CaO.	MgO.	Na_2O.	K_2O.	Loss.	Sp. Gr.
1.	57.25	16.45	1 67	1.77	7.65	6.74	3.00	1.57	0.45	
2.	53.81	13.48	3.02	7.39	10.34	6.46	3.23	0.64	0.57	2.75
3.	53.62	22.09	4.21	. .	6.02	6.24	3.16	0.57	5.03	
4.	52.27	17.68	2.51	5.00	8.39	6.05	4.19	1.58	0.82	
5.	51.58	11.92	2.96	13.05	8.52	4.09	0.95	0.34	1.52	2.989
6.	50.38	19.83	6.05	2.00	10.03	5.36	2.15	1.76	1.37	
7.	49.45	17.58	3.41	3.41	7.20	4.05	5.83	1.57	4.34	
8.	49.04	18.11	2.71	7.70	7.11	4.72	4.22	2.11	1.29	2.738
9.	48.40	17.95	2.28	8.85	10.05	6.99	2.86	1.03	0.34	2.8
10.	47.54	19.52	4.24	6.95	11.70	6.66	3.09	0.16		2.981
11.	46.43	17.10	11.16	. .	10.38	9.78	2.50	. .	2.65	
Diabases.										
12.	54.52	19.10	2.83	5.89	7.25	3.92	3.73	2.30.	0.59	2.7
13.	53.13	13.74	1.08	9.10	9.47	8.58	2.30	1.03	0.90	2.96
14.	49.28	15.92	1.91	10.20	7.44	5.99	3.40	0.72	3.90	2.86
15.	48.75	17.17	0.41	13.62	8.82	3.37	1.63	2.40	. .	2.985
16.	46.28	12.96	4.67	6.06	10.12	8.71	3.75		3.34	2.921
17.	45.46	19.94	15.36	. .	8.32	2.95	2.12	3.21	2.30	2.945
Limburgite.										
18.	46.90	10.17	1.22	5.17	6.20	20.98	1.16	2.04	5.42	2.86
19.	40.22	14.41	17.42	2.36	11.53	7.29	3.94	1.90	1.10	2.89
Nepheline-basalt.										
20.	38.35	9.18	20.32	. .	11.76	13 78	2.77	2.02	1.20	3.223

1. Basalt with quartz, Cinder Cone, Calif., J. S. Diller, A. J. S., Jan., 1887, p. 49, Anal. Hillebrand. 2. Kilauea, Sandwich Is.; Cohen., Neues Jahrb. 1880, II., 41. 3. Iceland, Schirlitz. Tsch. Mitt., 1882, 440. 4. Rio Grande Canon, N. M., J. P. Iddings, A. J. S., Sept., 1888, 220, Anal. Eakins. 5. Dalles, Oregon, Lemberg, Z. d. d. g. G. XXXV. 116. 6. Richmond Mtn., Eureka Dist., Nev., A. Hague, Mono, XX., U. S. G. S., 264, Analyst Whitfield. 7. Point Bonita, Calif., F. L. Ransome, Bull. Geol. Dept., Univ. Calif., I., 106. 8. Buffalo Peaks, North Park, Colo., Woodward, 40th Parallel Surv., II., 126. 9. Shoshone Mesa., Nev., Woodward, 40th Par. Surv., II., 617. 10. Cascade Mts., Oregon, Jannasch, Tsch. Mitth., 1881, 102. 11. Glassy basalt, Edgecombe Island, near Sitka, Alaska, Lemberg, Z. d. d. g. G., XXXV., 570. 12. Diabase Hills, Nev., Woodward, 40th Parallel Surv., I., Table opposite p. 676. 13. Penn., R. R. cut, Jersey City, N. J., G. W. Hawes, A. J. S., iii., IX., 186. 14. Lake Saltonstall, Conn., Ibid. 15. Dike near Boston, Mass., W. H. Hobbs, Bull. Mus. Comp. Zool., XVI., 1. 16. Point Bonita, Calif., F. L. Ransome, Bull. Geol. Dept., Univ. Calif., I., 106. 17. Dike at Palmer Hill, Ausable Forks, N. Y., J. F. Kemp, Bull., 107., U. S. G. S. 26. 18. Limburgite, Bozeman, Mont., G. P. Merrill, Proc., U. S. Natl. Mus., XVII., 640, Anal. Chatard. 19. Limburgite, Palma., L Van Werveke,

Neues Jahrb. 1879, 485. 20. Nepheline-basalt, Pilot Knob., near Austin, Texas, J. F. Kemp, Amer. Geol., Nov., 1890, 293.

Comments.—The first analysis is very like the more basic andesites, except in its high percentage of MgO. It is of a curious and exceptional basalt with quartz phenocrysts, regarding which, mention is made later. In general, the others are notably high in the oxides of iron, in CaO and MgO. The specific gravity is also high. The analyses of diabases differ in no essential from those of true basalts. No. 13 is of especial interest, as it is the one usually quoted as the representative of our Triassic diabases. The last three are representatives of the unusual varieties, later mentioned, that are of rare occurrence in the United States, but that represent the limiting percentages of SiO_2 in rocks mostly composed of silicates.

Mineralogical Composition. Varieties.—The name basalt is a a very ancient term and has been explained in several ways. Many regard it as a corruption of basanites which was used by Pliny, but for what rock is uncertain. The Greek word for the black touchstone or Lydian stone used by the ancient jewellers is similar to this last form. Others refer it to Basan or Bashan, the kingdom of Og, as mentioned in the Old Testament, Deuteronomy III., 1. Again an Ethiopian word "basal" used by Pliny for an iron-bearing rock, has been suggested. Agricola in the sixteenth century gave it its present signification.

It stands for a very large and important group, which has many mineralogical varieties, but which can seldom be subdivided without exact microscopical study. The name basalt, therefore, embraces them all when macroscopically considered. They are all heavy, black, gray or brown rocks, usually porphyritic, but at times lacking all phenocrysts and merely a closely crystalline dark rock. Plagioclase, augite, olivine and magnetite are the chief minerals present, and the groundmass is usually a finely crystalline aggregate of these and of some dark glass. At the acidic extreme of basalts are certain dark rocks, with abundant augite, that yet lack olivine. Though closely related to the augite-andesites, they are sometimes called *olivine-free basalts.* The typical basalt has, however, olivine, and often exhibits this mineral in large rounded masses. Coarsely crystalline basalts are called *dolerites*, a very common and useful field term. Typical dolerites are porphyritic but shade into granitoid varieties. An old group of rocks and one whose name often puzzles beginners as regards its special signifi-

cance is called diabase. The diabases are generally entirely crystalline and apparently of a granitoid texture. The feldspars are, however, in long and relatively narrow crystals, as contrasted with the broader ones of typical granitoid rocks. In the interstices of these lath-shaped feldspars are found the dark silicates and magnetite. The texture is called *ophitic* and is more especially of microscopic importance. There is, therefore, ground for difference of opinion as to whether the diabases should be placed with the granitoid or with the porphyritic rocks, but as they are always in sheets or dikes, which shade into porphyritic forms on the contacts, and which are really volcanic in their nature, they are put here as essentially basalts at the extreme of the group toward the granitoid division. In former times the name was only used for pre-Tertiary rocks; but as often stated, the time distinction has been long since exploded. There are both diabases and olivine-diabases, but really except in connection with microscopic work the term diabase is superfluous, while we have and use basalt, dolerite and gabbro. It is, however, so intimately involved with the literature of many important mining regions and others of great geological interest that the student should be familiar with its employment and its significance. The name is derived from the Greek verb meaning to penetrate or pass through, and was suggested by the dikes in which the early occurrences were met. Greenstone and trap are also old names chiefly applied to diabase.

Into many basalts, nepheline or leucite enter, and if in notable amount, with little or no olivine, the rock is called tephrite, or leucite-tephrite, if with much olivine, basanite or leucite-basanite; if with little or no olivine and no plagioclase, nephelinite or leucitite, and if there is much olivine, nepheline-basalt and leucite-basalt. The distinctions are, however, microscopic and in the field basalt is sufficient. Again the rocks may lack both the feldspar and the feldspathoids and consist merely of augite in a glassy groundmass, *i. e.*, augitite, or of augite and olivine in a glassy groundmass, giving limburgite, but these are also only of microscopic moment, although the significance of the names should be understood. Basalts with melilite are the rarest of the group.

Basalts rather rarely have hornblende, but when this is present it is a deep brown variety known as basaltic hornblende. Biotite is also uncommon, except in the varieties with nepheline or leucite. A most extraordinary basalt has been met by J. S. Diller and others

in our western volcanic regions that contains *quartz* in moderately large phenocrysts. The presence of this mineral in such basic rocks is most peculiar, but it is explained by assuming exceptional conditions of crystallization in the early history of the magma, leading to the separation of quartz which was never re-absorbed.

Alteration, Metamorphism.—The olivine of basaltic rocks is the first mineral to alter, and it soon becomes a network of serpentine veinlets enclosing unchanged nuclei. The augite also passes readily into chlorite and finally the feldspar kaolinizes. The prevalence of green, chloritic products suggested the name greenstone for the old diabases. The basaltic rocks are extremely important in connection with metamorphism, and the iron-mining regions around Lake Superior present superb illustrations of the process. The augite has the greatest tendency to pass into green hornblende, by what is called a "paramorphic" change, *i. e.*, a change in the mineral without change in the chemical composition and without, as in pseudomorphs, preserving the original form. Under shearing stresses and movements, accompanied by this paramorphic change, diabases, so-called, pass into hornblende-schists, and even chlorite-schists or green-schists, losing their massive structure entirely and becoming a very different rock, and one that can be traced to its original with great difficulty. Such hornblendic rocks are also called amphibolites.

Tuffs. Basaltic tuffs, agglomerates, breccias, etc., are well known and often accompany the massive flows. They mark an explosive stage of eruption before the actual outpouring of lava.

Distribution. Basaltic rocks are enormously developed in this country. The oldest strata are penetrated by numerous black, igneous dikes, in practically all their exposures. The New England seacoast is especially seamed by them, and hundreds may be met in a short distance. The Adirondacks and the White Mountains, the Highlands of New York and New Jersey, have many. In the East are the intruded sheets of Triassic diabase, up to 500 feet in thickness, forming many of the most prominent landmarks, such as Cape Blomidon, N. S.; Mts. Tom and Holyoke, Mass.; East and West Rock, near New Haven, Conn.; the Palisades on the Hudson, and many dikes in the Richmond, Va., and Deep River, N. C., coal fields. Around Lake Superior, both in the iron and in the copper regions, are still greater sheets, for many thousands of feet of basalt (diabase) are present on Keweenaw Point. On the

north shore near Port Arthur, the head-lands of Thunder Bay exhibit superb examples. The iron-bearing strata are penetrated by innumerable dikes. The greatest of all the American basaltic areas is, however, met in the Snake River region of southern Idaho and extends into eastern Oregon and Washington. Many thousands of square miles are covered with the dark lava and are locally called the "Lava Beds." In Colorado, as at the Table Mtns., near Golden, and Fisher's Peak, near Trinidad, there are prominent sheets, and the same is true of many other points in this State. In New Mexico, Arizona and Texas they are also met. The volcanoes of the Sandwich Islands are basaltic. Basaltic rocks with nepheline are scarcely known in the United States. Some minor dikes in the East, a volcanic neck at Pilot Knob, near Austin, Texas, dikes and sheets in Uvalde Co., Texas, and a few dikes at Cripple Creek, Colorado, are practically the only localities yet identified. Leucitic rocks, more phonolitic than basaltic, are known in the Leucite Hills, Wyo., and in Arkansas. Of basaltic affinities they occur in New Jersey, but these and the nepheline rocks are of small practical moment, although of great scientific interest.

Basalts have quite as great development abroad as here. The islands off the north coast of Scotland are famous localities, and many of the volcanic regions of the continent are no less well provided. The lavas of Etna are chiefly basaltic, and those of Vesuvius are remarkable for their richness in leucite. In India are the great basalt fields of the Deccan, which are comparable in extent with those of the Snake River region of the West.

CHAPTER V. THE IGNEOUS ROCKS, CONTINUED. THE DIORITES, GABBROS, PYROXENITES AND PERIDOTITES. ULTRA-BASIC IGNEOUS ROCKS.

THE DIORITES.

	SiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	CaO.	MgO.	Na_2O.	K_2O.	Loss.	Sp.Gr.
1.	67.54	17.02	2.97	.34	2.94	1.51	4.62	2.28	.55	
2.	65.27	15.76	1.36	3.44	2.14	4.57	3.97	. .	.42	
3.	61.75	18.88	0.52	3.52	3.54	1.90	3.67	1.24	4.46	2.79
4.	58.05	18.00	2.49	4.56	6.17	3.55	3.64	2.18	.86	
5.	56.71	18.36	. .	6.45	6.11	3.92	3.52	2.38	. .	2.86
6.	52.35	15.72	2.90	7.32	8.98	7.36	2.81	1.32	1.35	
7.	50.47	18.73	4.19	4.92	8.82	3.48	4.62	3.56	.58	2 87
8.	48.98	17.76	2.14	6.52	8.36	2.09	6.77	2.08	4.50	
9.	48.19	16.79	18.37	. .	6.85	1.32	5.59	1.11	2.31	

1. Quartz-mica-diorite, Electric Peak, Yellowstone Park, J. P. Iddings, Anal. by Whitfield, Bull. Phil. Soc. of Washington, II, 206. 2. Quartz-augite-diorite, Watab, Minn., A. Streng, Neues Jahrbuch, 1877, 232. 3. Diorite. Pen-maen-mawr, Wales, J. A. Phillips, Q. J. G. S., XXXIII, 424, 1877. 4. Diorite, see under No. 1. 5. Diorite, (granitoid andesite?) Comstock Lode, Nev., R. W. Woodward, 40th Par. Survey, I, opp. p. 676. 6. Augite-diorite, Little Falls, Minn., A. Streng, Neues Jahrb., 1877, 129. 7. Augite-diorite, Mt. Fairview, Custer Co., Colo., W. Cross, Anal. by Eakins, Col. Sci. Soc., 1887, 247. 8. Porphyritic-diorite, St. John, N. B., W. D. Matthew, Trans. N. Y. Acad. Sci., XIV, 213. 9. Diorite dike rich in magnetite, Forest of Dean Mine, N. Y., J. F. Kemp, A. J. S., Apr., 1888, 331.

Comments.—The analyses represent a series that is closely parallel with the dacites and andesites in the first five analyses, but that recalls the basalts and diabases in the last four. MgO rules lower than in the latter. It is evident that the prevailing feldspar would be a lime-soda variety, but that orthoclase might readily be produced, for even when we allow some for biotite the percentage of K_2O is notable. The parallelism with gabbros will be shown by the next table to be close.

Mineralogical Composition and Varieties.—The name diorite is derived from the Greek verb, meaning to distinguish in allusion to the fact that the hornblende and feldspar could be distinguished one from another in the coarsely crystalline ones first studied. Diorites are granitoid rocks consisting of hornblende, biotite and plagioclase. Those with hornblende are diorites proper, while those with biotite are called mica-diorites. Some augite is occasionally present, marking passages to the gabbros and giving the name augite-diorite. An intermediate type occurring in dikes, and containing both biotite and augite is kersantite. Acidic diorites often have considerable quartz, and are called quartz-diorites. Tonalite is a quartz-hornblende-diorite. Quartz-diorites shade insensibly into granites, and the importance of the intermediate forms or granite-diorites was emphasized under granite. These acidic diorites are prevailingly light in color, but the more basic ones become decidedly dark. Certain dikes with the minerals of diorite are called camptonites. The great tendency of augite to change to green hornblende causes a doubt to hang over the true character of many diorites. They may often be metamorphic products from gabbros or diabases.

Alteration, Metamorphism.—In ordinary alteration the feldspar of diorites kaolinizes and the hornblende changes to chlorite, affording one of the varieties of the so-called greenstones. In metamorphism the diorites pass into gneisses, under shearing stresses, and into

hornblende schists or amphibolites. In many mining regions even decidedly schistose varieties are still called diorite. A final stage is chlorite-schist, wherein the hornblende has altered to chlorite.

Distribution. True, original diorites are not very common rocks in America. A well known quartz-mica-diorite is extensively developed in a series of igneous rocks, called the Cortlandt Series, on both sides of the Hudson, below Peekskill. In the Sudbury nickel district, north of Lake Huron, dense, dark diorites are the chief rock containing the ore, but there is always the possibility that the hornblende is altered augite. Mt. Davidson, above the Comstock Lode, is either a true diorite or a granitoid phase of andesite. Authorities differ as to its interpretation. Granodiorites, the intermediate rocks between granite and diorite, are well recognized both in the East and the West.

Diorites are well known abroad and have been described from various places in Great Britain, Germany, France and Austria. The typical tonalite is obtained near Meran, in the Tyrol,

THE GABBROS, PYROXENITES AND PERIDOTITES.

Gabbro.	SiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	CaO.	MgO.	Na_2O.	K_2O.	Loss.	Sp. Gr.
1.	59.55	25.62	0.75	. .	7.73	tr.	5.09	0.96	0.45	2.66
2.	55.34	16 37	0.77	7.54	7.51	5.05	4.06	2.03	0.58	
3.	54.72	17.79	2.08	6.03	6.84	5.85	3.02	3.01	. .	2.928
4.	54.47	26 45	1.30	0.67	10.80	0.69	4.37	0.92	0.53	2.72
5.	53.43	28 01	0.75	. .	11.24	0.63	4.85	0.96	tr.	2.67
6.	52.14	29 17	. .	3.26	10.81	0.76	3.02	0.98	0.58	
7.	49.15	21.90	6 60	4.54	8.22	3.03	3.83	1.61	1.92	
8.	48.02	17.50	1.80	7.83	13.16	10.21	1.48	tr.	.79	
9.	46.85	19.72	3.22	7.99	13.10	7.75	1.56	0.09	.56	
10.	46.85	18.00	6.16	8.76	10.17	8.43	2.19	0.09	.30	3.097
11.	45.66	16.44	0.66	13.90	7.23	11.57	2.13	.41	.07	
Pyroxenite.										
12.	55.14	0.25	3.48	4.73	8 39	26.66	.30	. .	. .	
13.	53.98	1.32	1.41	3 90	15.47	22.59	. .	. .	0.83	3.301
14.	44.01	11.76	15.01	. .	4.06	25.25	. .	. .	. .	
Peridotite.										
15.	47.41	6.39	7.06	4.80	14.32	15.34	.69	1.40	2.10	3.30
16.	46.03	9.27	2.72	9.94	3.53	25.04	1.48	0.87	0.64	3.228
17.	41.00	7.58	. .	5.99	10.08	23.59	0.52	. .	4.73	2.989
18.	36.80	4.16	. .	8.33	8.63	25.98	0.17	2.48	0.51	
19.	33.84	5.88	7.04	5.16	9.46	22.96	0.33	2.04	7.50	
20.	29.81	2.01	5.16	4.35	7.69	32.41	0.11	0.20	8.92	2.78

1. Anorthosite, Chateau Richer, Canada, T. S. Hunt, Geology of Canada, 1863. 2. Norite, Cortland Series, Montrose Point, Hudson River, Anals. by Munn, for J. D. Dana,

A. J. S., Aug., 1881, p. 104. 3. Gabbro, near Cornell Dam, Croton River, H. T. Vulté, for J. F. Kemp, unpublished. 4. Anorthosite, Summit of Mt. Marcy, Adirondacks, A. R. Leeds, 30th Ann. Rep., N. Y. State Museum, reprint, p. 14, 1876. 5. Anorthosite, Nain, Labrador, A. Wichmann, Z. d. d. g. Ges., 1884. 6. Gabbro, Iron Mtn., Wyo., 40th Parallel Surv., II., 14. 7. Gabbro, near Duluth, Minn., Streng, Neues Jahrb, 1876, 117. 8. Gabbro-diorite, Baltimore, Md., average of seventeen samples, Mackay for G. H. Williams, U. S. G. S., Bull., XXVIII., 37. 9. Gabbro, Baltimore average of twenty-three samples, ibid. 10. Gabbro, Southwest Adirondacks, C. H. Smyth, Jr., A. J. S., July, 1894, 61. 11. Gabbro, Northwest Minn., W. S. Bayley, Anals. by Stokes, Jour. Geol. I., 712. 12. Pyroxenite, var. Websterite, Webster, N. C., E. A. Schneider for Geo. H. Williams, Amer. Geol., July, 1890, p. 41. 13. Pyroxenite, Baltimore, Md., T. M. Chatard for G. H. Williams, ibid. 14. Pyroxenite, Meadow Creek, Mont., Geo. P. Merrill, Proc., U. S., Nat'l Mus., XVII., 658. 15. Peridotite, Cortland Series, Montrose Pt., N. Y., Emerson for G. H. Willams, A. J. S., Jan., 1886, 40. 16. Peridotite, Custer Co. Colo., L. G. Eakins for W. Cross, Proc. Colo. Sci. Soc., 1887, 245. 17. Peridotite, Baltimore, Md., L. Mackay for G. H. Williams, Amer. Geol., July, 1890, 39. 18. Peridotite, Dewitt, N. Y., H. S Stokes for Darton & Kemp, Amer. Jour. Sci., June, 1895, 456. 19. Mica Peridotite, Crittenden Co., Ky., W. F. Hillebrand for J. S. Diller, A. J. S., Oct., 1892, 288. 20. Peridotite, Elliott Co., Ky., J. S. Diller, Bull. 38, U. S. G. S., p. 24.

Comments.—The range in composition presented by the gabbros is in many respects the same as that of the basalts. As a general rule the most feldspathic members (the anorthosites) are the highest in silica, Nos. 1, 4 and 5. No. 6, although described as gabbro, is doubtless of the same character, for the low FeO and MgO indicate few dark silicates. These rocks are also highest in Al_2O_3 of all the rock analyses yet quoted. As the pyroxenes and olivine increase in amount, the CaO and MgO also grow notably larger. In the gabbros of the Cortland series (Nos. 2 and 3) and in those near Duluth (No. 7) there is often considerable orthoclase as is indicated by the K_2O. The pyroxenites are remarkable for the falling off in Al_2O_3, due to the disappearance of feldspar, and for the increase in CaO and MgO of the pyroxenes. The peridotites reach a lower percentage of silica than any other igneous rocks so far cited, but if this is accompanied by high H_2O, allowance must be made for the relative decrease of the original SiO_2 in the change to serpentine. The great percentages of MgO are very notable, and are due to the presenec of much olivine, magnesian pyroxene and, in instances, biotite. Chromic oxide is also always present in small amounts, and oxides of nickel and cobalt are usually in perceptible quantity.

Mineralogical Composition, Varieties.—The name gabbro is of Italian origin, and has been applied of recent years, and with

growing favor to the great group of granitoid rocks consisting in the typical cases of plagioclase and pyroxene. The diabases, as explained under basalt, are now generally classed with the volcanic rocks, although texturally and mineralogically they really lap over true gabbros. The so-called gabbro group is a very large and characteristically variable one. Originally the name gabbro was only applied to a mixture of plagioclase and the variety of monoclinic pyroxene called diallage, that has pinacoidal as well as prismatic cleavages, but of late years all granitoid plutonic, pyroxene-plagioclase rocks are collectively spoken of as the gabbro group. At the acidic extreme we have in Canada and the Adirondacks enormous masses of rock that are practically pure, coarsely crystalline labradorite. Pyroxene is the dark silicate when any is present, but often it is insignificant. These pure feldspar rocks are best called *anorthosites*, from the French word for triclinic feldspar, but the word is not to be confused with anorthite, the lime-feldspar with which, it has no special connection. As monoclinic pyroxene increases they pass into gabbros proper. More or less biotite and hornblende may also be present. If the pyroxene is orthorhombic we call the rock norite. Varieties with olivine are frequent, giving olivine-gabbro and olivine-norite. Gabbros and norites are not readily distinguished without the microscope, unless the bronzy appearance of hypersthene can be recognized. Gabbro is then a good collective term. An old and obsolete synonym of anorthosite is labradorite-rock, of interest because widely used in the early reports on the Adirondacks. Norites were called hypersthene rock, or hypersthene-fels, both of which are undesirable rock names. Gabbro intrusions of not too great extent or irregularity for careful study have been observed to grow more basic toward the outer margins.

The gabbros pass insensibly, by the decrease of plagioclase, into the pyroxenites and peridotites, and in any great gabbro area all these are usually present, but they may occur also as independent masses. The pyroxenites are practically pyroxene, with little if any other minerals. There is some variety, according as the rock contains one or several of the following: enstatite, bronzite, hypersthene, diallage or augite; but with the unassisted eye, it is seldom that one can be sure of these distinctions, except as the orthorhombic pyroxenes exhibit a bronze luster. Hornblende, magnetite and pyrrhotite may also be present. With the accession of olivine,

peridotite results, so named from the French word peridot for olivine, and a number of varieties have been made according as the olivine is associated with one or more of the minerals cited for pyroxenites. The distinctions are however hardly possible without microscopic aid. As the extreme of peridotites we have a nearly pure olivine rock, called dunnite, important in North Carolina. Much magnetite may be associated with peridotite; indeed at Cumberland Hill, R. I., there is enough to almost make the rock an ore, Chromite, too, is a frequent associate. As peridotites shade into a porphyritic texture, especially in dikes, they have been called picrites, and even further varieties, such as kimberleyite, have been made. Black hornblende, which is brown in thin sections, is frequent in both pyroxenites and peridotites, and may even form a rock itself, hornblendite. Dark brown biotite is also often present in considerable amount.

Some writers have regarded the pyroxenites and peridotites as of doubtful igneous origin and have placed them with metamorphic rocks, but from their frequent association with gabbro, and from their independent occurrence in dikes, there is no good reason to doubt their true, igneous nature.

Alteration, Metamorphism.—The gabbros alter chiefly by the formation of serpentine and chlorite from the dark silicates. The pyroxenites and peridotites change readily into serpentine, often with an intermediate stage as hornblende-schist. Under dynamic stresses, especially shearing, anorthosites and gabbros pass into gneissoid type, and in the process much garnet may be developed. This is especially true in the Adirondacks. The larger feldspars may be left in the gneisses as "eyes," or to adopt the German term, as "Augen," affording Augen-gneiss, *i. e.*, gneisses with comparatively large lenticular feldspars. Much hornblende, especially in true gabbros, is often developed in the process. The basic members, the pyroxenites and peridotites develop amphibolites or hornblende-schists, which latter often furnish very puzzling geological problems.

Distribution.—The anorthosites are so far as we know limited to several Canadian areas, as at the headwaters of the Saguenay river, and again north of Montreal; and to the higher peaks of the Adirondacks and some of their outliers. Mt. Marcy and its eighbors consist of them. Gabbros are also present in vast quan-y, and are likewise well known in the White Mountains, in the

famous Cortlandt series, near Peekskill, on the Hudson, and in the vicinity of Baltimore. Around Lake Superior gabbros are of great importance, as the basal members of the Keweenawan system and other older intrusions are largely formed of them. Fine specimens can be had at Duluth. They are a characteristic wall rock of titaniferous magnetite. Pyroxenites occur as subordinate members of the gabbro areas, especially near Baltimore. Peridotites are in the same relations in the Cortlandt series, in the Baltimore area and in North Carolina. They are also known on Little Deer Island, Me., at Cumberland Hill, R. I., in the dikes near Syracuse, N. Y., at Presqu' Isle, near Marquette, Mich., in Kentucky, in California and elsewhere in the West.

Abroad, anorthosites and gabbros are abundant in the Scandinavian peninsula, whose geology is in many respects like that of Canada and the Adirondacks. In the north of Scotland gabbros are of especial interest because they have been shown by Judd to be the deep-seated representives of the surface basalts. On the continent they are important rocks in many localities. The same is true of Australia and such other parts of the world as have been studied. Of especial interest are the peridotite dikes in South Africa that have proved to be the matrix of the diamond.

Ultra-Basic Igneous Rocks. Meteorites.

A few ultra basic igneous rocks are known in which the silica decreases almost to nil, and in which the bases, especially iron, are correspondingly high. They are in general rather to be considered as basic segregations in a cooling and crystallizing magma than as individual intrusions. The Cumberland Hill, R. I., so-called peridotite, cited above, has very little silica. Titaniferous ores have almost none, but they are often exceptionally rich in alumina. In a few cases metallic iron has been detected in basic igneous rocks, suggesting analogies with meteorites.

Meteorites are rare and only of scientific interest, but it is extremely suggestive that such silicates as are met in them are chiefly olivine and enstatite, minerals rather characteristic of very basic rocks. The commoner meteorites are an alloy of metallic iron and nickel, but some rare sulphides are occasionally present.

As filling out the theoretical series we cannot bar out water and ice. There is no reason why they are not to be considered igneous rocks of extremely low fusing point, but they are so familiar that a simple reference to them is sufficient.

NOTES ON THE ASSAY OF RICH SILVER ORES.

By EDMUND H. MILLER and CHARLES H. FULTON.

The object of this work is to locate the loss of silver in the different operations, essential to the assay of a rich silver ore, by determining the amounts which can be recovered from the slags and cupels. Also to determine the best method of assaying two particular ores.

Ore No. 1 is a cerussite, very rich in silver, containing .28 of an ounce of gold per ton, and about 28 per cent. of lead. The reducing power is .2 of a gram of lead per gram of ore.

Crucible Assays.

Two sets of crucible assays were made on this ore in order to determine the proper size of the lead button to give the highest result in an uncorrected assay, also to determine whether the amount of lead reduced in order to ensure the maximum result depended upon the amount of the charge.

In the first set, marked C_1, C_2, C_3, etc., the charge was: Ore ½ A. T., soda ($NaHCO_3$) 1 A. T., silica 1 A. T., litharge 2 A. T. The reducing agent used was argol; this was increased half a gram in each assay, so as to give a series from .5 to 3.0 grams.

The assays were made in ordinary round Hessian crucibles, and were heated in a hot coke fire for thirty-eight minutes. For the weights of the buttons and results see Table 1.

The buttons were cupelled at a red heat, lower than that ordinarily employed, but not so low as to give feathers. The cupels were ground up separately, mixed with litharge 2 A. T., soda 1 A. T., borax glass 1 A. T., argol 2 grams, fused, and the resulting buttons cupelled as usual. The cupel and slag were saved from each to be used for a second correction.

The crucible slags were ground separately and remelted with litharge 1 A. T., argol 2 grams, and the buttons cupelled as usual. These slags and cupels were also saved for a second correction.

In one assay, C_5 the button from the crucible assay was scorified from twenty-eight to twenty grams; the slag from the scorifier was ground, then mixed with litharge 1 A. T., soda 1 A. T., silica ½ A. T., argol 2 grams, and assayed as usual.

Two second corrections were made on this set of assays: One by combining the cupels and slags from the first corrections of assays C_1 and C_3, grinding and mixing with litharge 5 A. T., soda 3 A. T., borax glass 3 A. T. and argol 2 grams. The resulting button weighed forty grams, on account of the carbonaceous material used in making the cupels and was scorified to twenty-one grams before cupellation. The second was made in the same way by combining the cupels and slags from the corrections on C_2 and C_4.

In the second set of assays the fluxes were increased so as to double the charge used in the first set. The charge used was: Ore. .5 A. T., litharge 4 A. T., soda 2 A. T., silicia 2.5 A. T. The argol increased from .3 to 2.5 grams. The assays were run at a lower heat than in the first set; many of the cupels showed feathers.

The cupels and slags were reassayed as already described. The second corrections were made as before. In the assay marked, $2C_4$, the lead button was scorified from twenty-eight to twenty-one grams, and the scorification slag assayed as in the first set. In $2C_5$ the button was scorified from thirty-two to twenty grams, and the slag assayed. The assays of this set are marked, $2C_0$–$2C_5$.

In calculating the results expressed in the tables, allowance has been made for the litharge; the gold has been disregarded, as it amounts to less than the variation in the litharge. All percentages are calculated on 2260 ounces of silver per ton, which is the nearest even number to the average of the highest corrected values. (See table next page.)

In comparing the weights of the lead buttons reduced by the same amount of argol in the two sets we see a constant increase of about four grams in the second set. This is undoubtedly due partly to the difference in the heat of the fires, but also to some extent to the increased quantity of litharge. This fact is emphasized by determining the reducing power of the ore with the same amounts of litharge as used in the two sets of assays.

Lead reduced by fifteen grams of ore, 2 A. T. litharge present, 1.624 grams.

Lead reduced by fifteen grams of ore, 4 A. T. litharge present, 3.377 grams.

These assays were made in the same fires, the buttons were cupelled and the silver deducted.

CRUCIBLE ASSAYS. ORE NO. I. CERUSSITE. TABLE I.

Amount of Ore.	Argol.	Litharge.	Temperature of Furnace.	Weight of Lead Button.	Mark.	Temperature of Cupellation.	Weight of Silver in Milligrams.	Silver from Cupel.	Silver from Scorifying.	Silver from Crucible Slag.	Silver from 2 slags and 2 cupels, 2d correction.	Corrected value ounces Silver per ton.	Per cent. recovered from cupel.	Per cent. recovered from Scorification.	Per cent. recovered from crucible slag.	First correction, per cent.	Second correction, per cent.	Per cent. in 1st Silver Button.	Per cent. not recovered.	Mg's of Silver recovered from cupel per gram lead button cupelled.
½ A.T.	.5 gms.	2 A.T.	Hot	4.9 gms.	C_1	Red Heat	974.16	8.84		73.10	7.56	2119.76	.782		6.469	7.251	.335	86.209	6.21	1.80
½ A.T.	1.0 gms.	2 A.T.	Hot	12.2 gms.	C_2	Red Heat	1073.10	13.18		27.70		2235.52	1.16		2.451	3.517	.335	94.994	1.184	1.08
½ A.T.	1.5 gms.	2 A.T.	Hot	16.5 gms.	C_3	Red Heat	1088.58	13.32		15.88	5.60	2241.16	1.178		1.405	2.583	.248	96.361	.808	.80
½ A.T.	2.0 gms.	2 A.T.	Hot	23.6 gms.	C_4	Red Heat	1093.60	14.14		8.58		2238.54	1.250		.76	2.01	.248	96.779	.963	.60
½ A.T.	2.5 gms.	2 A.T.	Hot	28.0 gms.	C_5	Red Heat	1099.34	10.80	9.42	4.08		2247.28	.956	.832	.361	1.788		97.287	.925	.59
½ A.T.	3.0 gms.	2 A.T.	Medium	34.0 gms.	C_6	Red Heat	1089.08											96.378	3.622	
½ A.T.	.3 gms.	4 A.T.	Medium	5.4 gms.	2 C_0	Red Heat	1026.06											90.801	9.199	
½ A.T.	.5 gms.	4 A.T.	Medium	9.1 gms.	2 C_1	Feathers	1089.95											96.456	3.544	
½ A.T.	1.0 gms.	4 A.T.	Medium	16.0 gms.	2 C_2	Feathers	1093.66	13.14		21.04	6.22	2261.90	1.16		1.86	3.02	.275	96.784	—0.079	.82
½ A.T.	1.5 gms.	4 A.T.	Medium	22.5 gms.	2 C_3	Low Heat	1093.75	14.84		13.42		2250.24	1.312		1.19	2.502	.275	96.791	.432	.66
½ A.T.	2.0 gms.	4 A.T.	Medium	28. gms.	2 C_4	Feathers	1089.20	10.00	2.04	5.78	3.44	2217.48	.884	.18	.511	1.575	.15	96.390	1.885	.50
½ A.T.	2.5 gms.	4 A.T.	Medium	32. gms.	2 C_5	Feathers	1049.15	11.54	18.42	8.32		2178.30	1.022	1 630	.736	3.388	.15	92.841	3.620	.572
½ A.T.	3.0 gms.	2 A.T.	Medium	33. gms.	C_6^{1A}	Red Heat	1080.60											95.628	4.372	
½ A.T.	3.0 gms.	2 A.T.	Medium	31.5 gms.	C_6^1	Red Heat	1112.84	11.62		4.56		2258.04	1.028		.403	1.431		98.481	.088	.369
½ A.T.	.5 gms.	4 A.T.	Medium	11. gms.	2 C_{1A}	Feathers	1113.82	9.65		11.40		2269.74	.854		1.00	1.854		98.568	—0.422	.877

Increasing the litharge increases very slightly the silver in the slag.

In both sets the amount of silver obtained from the lead button increases regularly with the increase in the size of the lead button, to a maximum at about twenty-eight grams, then diminishes, as the greater loss in scorifying down or cupelling a larger button more than compensates for any increase in the amount collected.

The collecting power of a given weight of lead seems to be independent of the amount of the charge.

In the first set the weight of the charge was 4.5 A. T. In the second 9 A. T.

FIRST SET.

16.5	gram	button	gave	1088.58	millegrams.
23.5	"	"	"	1093.60	"
28.0	"	"	"	1099.00	"

SECOND SET.

16.00	gram	button	gave	1093.66	millegrams.
22.5	"	"	"	1093.75	"
28.0	"	"	"	1089.20	"

1st. Set: Average weight of button 22.66 gms., Silver 1097.17 mgs.
2d. Set: Average weight of button 22.16 " Silver 1092.20 "

In cupellation the absorption of silver by the cupel increases with the size of the button, but the amount recovered per gram of lead button cupelled diminishes regularly.

The loss in diminishing the size of a button by scorification is irregular, but usually greater than the loss if cupelled direct. To test this point two assays, C_6^1 and C_6^{1A}, were run under the same conditions; the buttons weighed thirty-three and thirty-four grams, the one from C_6^1 was cupelled direct and gave 1089.08 millegrams of silver, the other from C_6^{1A} was scorified to fifteen grams and then cupelled, this gave 1080.60 millegrams of silver.

The silver recovered from the crucible slag dimimishes as the silver in the original button increases, as would be expected, however, the highest ordinary assays always give the highest corrected assays; it is impossible by any number of corrections to make up for the deficiency of silver in the original button, though the corrected assays agree more nearly than the uncorrected.

Average results of crucible assays:

Average of C_2, C_3, C_4 and C_5,	uncorrected	2177.30	oz. per ton.
" " " " " " "	corrected	2240.55	" " "
" " $2C_2$, $2C_3$ and $2C_4$,	uncorrected	2184.40	" " "
" " " " " "	corrected	2243.18	" " "

Silver recovered from cupel, average of seven buttons, weighing from sixteen to thirty-one grams, 12.54 millegrams, average silver present 1086.75 millegrams.

Average per cent. 1.109.

Average amount of silver recovered from slags of same assays, 10.48 millegrams.

Average per cent. .927.

Average percentage same assays:

Ist. correction, 2.026; 2d. correction, average of four, .252.

Average millegrams of silver recovered per gram of lead button cupelled .65, silver present, 1086.75 millegrams.

The assays marked C_6 and $2C_{1A}$ are abnormal, they are placed at the bottom of the table as the corrections made on them appear in the averages.

Scorification Assays.

Twelve scorification assays were run to compare the results by this method with those obtained from the crucible. The charge in every assay was .1 A. T. ore and .5 of a gram of borax glass; the test lead ranged from thirty to sixty grams. The charges were made up by placing one-half of the test lead in the scorifier, then the ore, then the rest of the test lead and the borax glass on top.

As the results from the first set were very irregular a second set was run and the corrections made on the slags and cupels from these, also a second correction as in the crucible assays. The charges used were similar to those already described.

In one assay, S_4^1, the slag and cupel were assayed together, the reagents added were litharge 2 A. T., soda 2 A. T., borax glass 1.5 A. T., argol 2.5 grams.

In the following table all percentages are calculated as in table 1 on 2,260 ounces per ton. (See table opposite page.)

The results expressed in table 2 show at least one fact conclusively, that thirty grams of test lead are not sufficient for such a

SCORIFICATION ASSAYS. ORE NO. I. CERUSSITE. TABLE II.

Amount of Ore.	Borax Glass.	Test Lead.	Temperature of Scorification.	Weight of Lead Button.	Mark.	Temperature of Cupellation.	Weight of Silver.	Silver from Cupel.	Silver from Scorification Slag.	Second correction, 2 slags, 2 cupels.	Corrected value, oz. per ton.	Per cent. recovered from cupel.	Per cent. recovered from scor. slag.	First correction, per cent.	Second correction, per cent.	Per cent. in 1st Silver Button.	Per cent. not recovered.	Average uncorrected value, oz. per ton.	Mg's of Silver recovered from cupel per gram lead button cupelled.	Per cent. Ag. recovered per gram lead button cupelled.
1/10 A.T.	½ gm.	30 gms.	Bright Red	6.1 gms.	S_1^1		153.75									71.95	18.05	1626.35		
1/10 A.T.	½ gm.	30 gms.	Bright Red	6.7 gms.	S_1^2		171.52													
1/10 A.T.	½ gm.	40 gms.	Bright Red	8.5 gms.	S_2^1		211.96									94.87	5.13	2144.2		
1/10 A.T.	½ gm.	40 gms.	Bright Red	13.1 gms.	S_2^2		216.88													
1/10 A.T.	½ gm.	50 gms.	Bright Red	20.1 gms.	S_3^1		201.20									89.67	10.33	2026.5		
1/10 A.T.	½ gm.	50 gms.	Bright Red	18. gms.	S_3^2		204.10													
1/10 A.T.	½ gm.	60 gms.	Bright Red	32.6 gms.	S_4^1		212.52	(5.7)			(2182.20)			2.52		94.98	5.02	2146.6		
1/10 A.T.	½ gm.	60 gms.	Bright Red	27.2 gms.	S_4^2		216.80													
1/10 A.T.	½ gm.	30 gms.	Bright Red	11.5 gms.	$2\,S_1^1$	Feathers	175.88	5.96	13.22			1.119	2.92	4.04		83.97	11.99	1897.9	.32	.070
1/10 A.T.	½ gm.	30 gms.	Red Heat	4.4 gms.	$2\,S_1^2$	Feathers	203.70													
1/10 A.T.	½ gm.	40 gms.	Bright Red	13.0 gms.	$2\,S_2^1$	Feathers	199.10	5.49	15.12	3.42	2130.95	1.21	3.34	4.55	.75	88.97	5.59	2014.	.26	.058
1/10 A.T.	½ gm.	40 gms.	Red	7.5 gms.	$2\,S_2^2$	Low Heat	203.06													
1/10 A.T.	½ gm.	50 gms.	Bright Red	15.0 gms.	$2\,S_3^1$	Low Heat	200.80	6.80	13.02	1.88	2177.70	1.504	2.88	4.38	.41	91.55	3.66	2069.2	.25	.056
1/10 A.T.	½ gm.	50 gms.	Red	11.5 gms.	$2\,S_3^2$	Feathers	213 04													
1/10 A.T.	½ gm.	60 gms.	Bright Red	27. gms.	$2\,S_4^1$	Low Heat	201.90	7.96	9.84	2.15	2168.65	1.760	2.175	3.935	.47	91.54	4.05	2068.9	.15	.034
1/10 A.T.	½ gm.	60 gms.	Red	24. gms.	$2\,S_4^2$	Feathers	211.88													

rich ore, also that a very careful regulation of the heat is necessary—this is made evident by comparing the assays of the second set with the duplicates marked 2, which were run in a different muffle at a slightly lower heat and were cupelled with feathers. These average 135.5 ounces per ton higher in silver.

The silver from the cupel increases with the size of the button cupelled, as in the crucible assays. The silver from the scorification slag is irregular; it probably depends to a great extent on the heat at which the scorification was made.

Average results:

Average silver recovered from cupel 3.16 millegrams.

Average silver present 201.2 millegrams.

Average silver recovered from slag 6.40 millegrams.

Average second correction 1.24 millegrams.

Average from cupel 1.398%.

Average from slag 2.804%.

Average 1st correction 4.2%.

Average 2d correction .549%.

Average millegrams of silver recovered per gram of lead button cupelled .245.

A comparison of these results shows the amount recovered from the scorification slag to be three times that recovered from the crucible slag.

Average of four 30 grams test lead 1754.6 oz.

Average of four 40 grams test lead 2075.0 "

Average of four 50 grams test lead 2047.85 "

Average of four 60 grams test lead 2107.75 "

Average of six, 1st set, uncorrected 2105.80 "

Average of six, 2nd set, uncorrected 2049.63 oz.

Average of six, 2nd set, corrected 2159.1 "

The results show the marked superiority of the crucible assay for this ore, and confirm our experience with other pure basic silver ores.

All results point to a large loss of silver by volatilization during scorification in pure ores, as the corrected assays by the scorification method are very much lower than the crucible assays.

The second corrections are of interest, as they show that there is still considerable inaccuracy in a corrected assay of rich argentiferous material. We do not think it practicable to carry the corrections any further, as the size of the charge would make it very inconvenient.

ORE No. 2.

This is a very rich sulphide of silver carrying gold.

Crucible Assays–Nos. 1 and 2. Charge, ore .1 A. T., litharge 1 A. T., soda .5 A. T., silicia, 10 grams, argol 1.5 grams. The assays were made in small Hessian crucibles and were fused in a moderate fire for thirty minutes.

Nos. 3 & 4. Charge, ore .1 A. T., litharge 4 A. T., soda 1 A. T., silicia 1 A. T., argol 1.5 grams. These were fused for forty minutes.

Scorification Assays. A & B. Charge, ore .05 A. T., borax glass .5 grams, test lead 40 grams. Arranged as described under ore No. 1.

C & D. Same as preceding except 60 grams of test lead were used.

All these scorification were run at a low heat. Some of the irregular results were caused by scales of metallic silver which should have been removed.

The charges for the first and second corrections were essentially those already given. Two strengths of nitric were used in parting, first 1.16 Sp. Gr., then 1.26 Sp. Gr. (For results see table 3, next page.)

CRUCIBLE ASSAYS.

Average uncorrected assays		Silver	17106.95	oz.	Gold	241.12	oz.
" corrected "		"	17198.00	"	"	241.42	"
" percentages from slag		"	.143	"	"	.0515	"
" " " cupel		"	.711	"	"	.0725	"
" percentage 1st. correction		Silver	.926	"	"	.124	"
" " 2d. "		"	.0705	"	"	——	

SCORIFICATION ASSAYS.

Average uncorrected assays	Silver	16937.2	oz.	Gold	241.5	oz.
" " "	"	17178.0	"	"	242.25	"
" percentage from slag	"	.7255	"	"		
" " " cupel	"	.8635	"	"	} .31	"
" " 1st. correction	Silver	1.826	"	"	} .31	
" " 2d. "	"	.237	"	"	——	

The effect of an increase in litharge seems to be the same as in ore No. 1.

Scorification on ore No. 2 gives irregular but fairly high results, but the loss of silver in the scorification slag is still much greater than in the crucible. The reason that scorification gives better results with the sulphide than the carbonate may be that the silver

JCIBLE ASSAYS. ORE NO. 2, ARGENTITE CARRYING GOLD. TABLE III.

Amount of Ore.	Argol.	Litharge.	Weight of Lead Button.	Mark.	Weight of Silver.	Weight of Gold.	Silver recovered from crucible slag.	Gold recovered from crucible slag.	Silver recovered from cupel.	Gold recovered from cupel.	Second correction from cupel and crucible slags.		Corrected value, oz. Silver per ton.	Corrected value, oz. Gold per ton.	Per cent., recovered from cupel		Per cent., recovered from crucible slag.		Per cent., second correction cupel and slag.		Per cent., total, correction.		Mg'ms of Silver recovered from cupel per gram lead button cupelled.	Mg's of Gold recovered from cupel per gram lead button cupelled.
											Silver	Gold.			Silver	Gold.	Silver	Gold.	Silver	Gold.	Silver	Gold.		
1/10 A.T.	1½ gms.	1 A.T.	20 gms.	1	1711.59	24.16	3.77	0.03	24.11	0.03	2.06	. .	17198.0	241.30	.694	.062	.108	.062	.059	. .	.861	.124	.60 mg's	.00075
1/10 A.T.	1½ gms.	1 A.T.	20 gms.	2	1723.37	24.09																		
1/10 A.T.	1½ gms.	4 A.T.	21 gms.	3	1678.10	23.80	6.42	0.02	25.36	0.04	2.84	. .	17268.35	241.425	.730	.083	.179	.041	.082	. .	.991	.124	.54 mg's	.00088
1/10 A.T.	1½ gms.	4 A.T.	22½ gms.	4	1729.72	24.40																		
SCORIFICATION ASSAYS.																								
	Borax Glass.	Test Lead.					From scorification slag.	From scorification slag.			From cupel and scorification slags.						From scorification slag.							
1/20 A.T.	½ gms.	40 gms.	12.5 gms.	A	864.48	12.02	13.09	0.03	11.80	0.02	3.86	. .	17363.9	241.5	.679	.082	.754	.124	.222	. .	1.655	.206	.56 mg's	.00095
1/20 A.T.	½ gms.	40 gms.	8.5 gms.	B	843.16	12.08																		
1/20 A.T.	½ gms.	60 gms.	26 gms.	C	830.96	12.04	12.12	0.10	18.20	tr.	4.38	. .	16993.4	243.0	1.048	tr.	.697	.414	.252	. .	1.997	.414	.36 mg's	. . .
1/20 A.T.	½ gms.	60 gms.	24 gms.	D	848.84	12.16																		

is taken into slag as an oxide and that the sulphur present uses up a part of the oxygen leaving less to react on the silver.

The amount of gold recovered is very small in either assay, but as far as can be judged from so few experiments, it is greatest in the scorification assay.

Conclusion.

The silver recovered from the cupel is usually more than from the crucible slag; it increases regularly with the size of the button, but not in a direct proportion. This is best shown by dividing the millegrams recovered by the weight of the button cupelled; the results so obtained decrease regularly as the weight of the button increases, when the same amount of silver is present. See tables.

Feathers are not in all cases a correct indication of temperature, but depend to some extent on the position of the cupel in the muffle.

The best method of assaying should be worked out for each ore, but, according to our experience, the following conclusions are warranted:

1. The crucible assay is the best for all gold ores and for silver in pure ores, particularly those having a basic gangue.

2. Uncorrected scorification assays are higher than uncorrected crucible assays for impure materials (sulphides, etc.) carrying silver.

3. The corrected crucible assay is usually slightly higher than the corrected scorification assay, because of the loss of silver in scorification by volatilization.

Comparison of our results with those recently published.

Ore No. 1 Silver.

	Av. loss in slag.	Av. loss in cupel.	Av. loss 1st. Cor.	Av. loss 2d Cor.	Av. loss total Cor.
Scorification	2.804%	1.398 %	4.202%	.54%	4.742 %
Crucible	.927 "	1.109 "	2.036 "	.252%	2.288 "

Ore No. 2 Silver.

Scorification	.7255%	.8635 %	1.589%	.237%	1.826%
Crucible	.1435 "	.712 "	0.855 "	.07 "	0.926 "

Ore No. 2 Gold.

Crucible .	.0515%	.0725%	.124%.
Scorification. . .		. .	.31%.

Mason & Bowman* give the losses of gold and silver by scorification and cupellation, determined by difference on the pure metals, as follows:

	Loss in Scorification.	Loss in Cupellation.	Total Loss.
Silver	.55%	1.99%	2.54%
Gold	.574%	.296%	.87%

F. P. Dewey† states that the amount recovered by correcting the assay of a lead carbonate, running from one hundred to five hundred ounces of silver, is 2.60%; amount recovered by correcting the scorification assays of precipitated sulphides (Russel process), running 17,500 ounces per ton, is 1.26%.

C. A. Stetefeldt‡ gives the amount recovered by correcting the assay of lead carbonate, one hundred to five hundred ounces of silver, as 2.9%: for precipitated sulphides 1.20%.§

Furman‖ gives the average losses in the crucible assay, determined by difference on the pure metals, as 2.58% for silver and .30% for gold.

A set of experiments to show the percentage of loss in both scorification and cupellation which can be recovered by assaying the cupel or slag would be of great interest. These figures would form the essential link between the results of Mason, Furman and others, and those of Dewey, Stetefeldt, etc. This has been done in the case of the loss of gold in cupellation by Rose,¶ who states that 82% of the gold lost is absorbed by the cupel.

In the preceding table no attempt has been made to give more uniform results by omitting assays, but the results of every assay made are given.

Assay Laboratory, January 13, 1896.

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* J. Am. Chem. Soc., vol. 16, p. 313.

† J. Am. Chem. Soc., vol. 16, p. 513.

‡ Trans., vol. 24, p. 537.

§ These results should be compared with our first, not total corrections.

‖ Trans., Vol. 24, p. 735.

¶ J. Am. Chem. Soc. vol. 63, 1893, p. 710.

AN EXPLOSION IN A ZINC-FUME CONDENSER.

By CHAS. F. McKENNA, PH. D.

An explosion took place about eight o'clock on the morning of July 6th, 1895, at the Spiegleisen furnace of the Passaic Zinc Co., on the plank road, near Newark, N. J. This plant was designed by Arthur F. Wendt, and erected in 1883, to treat the residuum obtained from the Wetherill furnaces at the Company's works in Jersey City. It consists of a blast furnace, an extensive system of condensers, the hot-blast ovens and the engine and boiler plant. In 1893 the blast furnace was torn down and reërected. It is now 37 feet to the stock line, with 6 feet 9-inch hearth, and 10-feet bosh. It is water-cooled to the mantel. The tuyeres are 5 feet 6 inches above the hearth, and are six in number with 3½-inch nozzles. The capacity of the furnace is 2,323 cubic feet, its daily product 20 to 21 gross tons of Spiegel. It is charged through a bell and hopper. The blast is furnished by a Weimer blowing engine at a rate of 2,200 cubic feet per minute, a pressure of 5 pounds and a temperature of 882° F.

As is well known, the ores used in the Wetherill furnace are the zinc-iron-manganese ores of Franklin and Sterling Hill, N. J. Being charged on the grate with fine anthracite and yielding up the zinc to form oxide, they are withdrawn as clinker, and this is sent to the blast furnace, being the only ore used therein to make the spiegeleisen.

The content of iron in this clinker or residuum is generally about 25%, and of manganese 12%, but the proportion of zinc is such as to explain the unusual nature of the working of this blast furnace. An analysis of an average lot charged about this time will show this:

Iron	25.51%,	as sesquioxide . . .	36.43%.
Manganese	12.26%,	as protoxide	15.83%.
Zinc	7.91%,	as oxide	9.85%.

Zinc has at times reached as high as 9.52%, or 11.85% oxide. These elements again are present in considerable proportion as silicates, and this, combined with the high percentage of zinc, renders it extremely difficult to sustain the heat in the furnace,

and furnishes an equally difficult problem in the disposition of the fume.

The zinc in the residuum being reduced and volatilized in the lower part of the furnace is partly oxidized again and carried off with the escaping gases. But not all is thus oxidized, for large amounts are carried over as "blue powder," containing sometimes 90 % of metallic zinc in an extremely fine state of division, and, like many other oxidizable bodies, when in this physical condition, quite ready to burst into active combustion. W. Hempel * has shown that in a shaft furnace zinc oxide may be reduced at a temperature lower than the boiling point of zinc and escape in an atmosphere of neutral or reducing gases; and also that in a zinc fume from such a furnace, coherent masses are formed by sudden cooling of the vapor, and only an impalpable powder when the cooling is not sudden and there is a large dilution of the vapor with other gases. In this furnace the concretions are formed about the throat where a sudden drop in the temperature takes place and these must be periodically broken away; but the major part of it, escaping in an atmosphere of neutral or reducing gases through the downcomer deposits this blue powder in the boxes of the condensers, which form an extensive and important part of the plant and in one of which the destructive explosion here referred to took place.

These condensers are composed of two sets, in order that one can be cleaned while the other is in use. A set consists of eight clusters of nine vertical pipes, connected at top and bottom with separate rectangular cast-iron chambers. Thus there are 72 pipes and 16 boxes in each set. The pipes are made of sheet steel, are 12 in. diameter and, 23 feet long. The bottom chambers or boxes are 4 ft. 10 in. square and 7 ft. 3 in high. The lower boxes have about one-third this space built up with brick, having a slope to the discharging door, because it had been found that their capacity was too great. These doors at the bottom are 2 ft. by 3 ft., hung at top, and when the furnace is stopped to clean out a condenser, they are free to blow open. At the top there are nine circular openings, 11 in. diam., on which there are lids weighing about 50 lbs. each, also free to open out. From the last box in the set, a gas-flue 36 in. diameter, leads to the hot-blast ovens and the boilers.

On the morning of the day mentioned, the Superintendent had ordered the furnace stopped and the valve changed in the main

* Berg. u. Huttenm., ztg. 1893. s. 355.

pipe from the downcomer and in the gas-flue, so that the set of condensers which had been in use for some days could be cut off. A door in the lower boxes being now opened and a block put in to hold it so, some of the lids on the top boxes were opened, when a slight explosion took place, throwing out the block from the lower door so that this fell closed. Thereupon, in a moment or two, came a dreadful explosion which wrecked one end of the set, threw the broken castings about and covered the Superintendent and his men with the pyrophoric zinc fume in active combustion. One man died from his injuries; the others subsequently recovered, although their burns had been, in one or two cases, so severe as to leave little hope of such a fortunate outcome.

Much interest was taken by metallurgists in this explosion, and since extreme precautions are always taken and were carefully observed on this occasion to prevent accident, it would seem as though there had been some unusual conditions present. Many like effects in a small way had often been observed in this and the other furnaces working similar ores, yet nothing approaching it in force and seriousness had ever been known, and full explanations were hard to find. Puffs of slight explosive force coming from the fume in the horizontal pipes leading to the condensers are often observed when air leaks through the valves or cleaning holes. But the mere combustion of the zinc powder is not continuous, and is, perhaps, stopped by other deposits of inert oxide. It has been thought that air leaking back would carry so much moisture that the latter would be decomposed by the zinc and the gases would reunite with explosive force. This gains some probability from the records of the Weather Forecaster at New York, which show that at 8 A. M. on July 6, 1895, the humidity was 93% with foggy atmosphere (practically, then, a saturated one), and the absolute humidity was 6.14 grains Troy to the cubic foot.

But the condensers have often been changed before and since this accident under similar weather conditions without any serious results.

It would seem that the composition of the furnace gases left in the condensers when shut off was just sufficient to make, with a small quantity of air leaking in, an explosive mixture which was fired by the first particle of zinc which showed the pyrophoric tendency. Again, it may be that both these facts are true, namely, the presence of gases nearly of the composition for explosion, and

the addition to them of the requisite hydrogen and air from a small quantity of moist air leaking in and acting upon the zinc. Then, with a closed box and a "touch-off," the disastrous effect would be complete. Such an explosion probably took place in this case, because it was one box, an upper one, which was smashed, indicating that it acted as a sort of pocket for explosive gas.

In the subsequent working of these condensers efforts were made to allow them to cool before cleaning, being entirely shut up, so that this tendency of the blue powder to ignition would be restrained until there was less danger of setting off combustible gas; two or three such changes were made with success, but again slight explosions were noticed.

Mechanical arrangements have since been provided for operating the bottom and top lids from a safe distance, and the practice is now to sweep the residual gases from the condensers as quickly as possible after the set has been shut off. This has been successful.

As with all pyrophoric materials, it is extremely difficult to prevent spontaneous combustion even when the blue powder is quite cool, for its particles are as fine as bolted flour, and the air space in a mass of it relatively large. Compressing it under 20 tons pressure consolidates the metal, giving it somewhat of a metallic lustre, and prevents entirely the tendency to explosive combustion. A button of it so compressed, can be heated in the air over a Bunsen burner, and will change to oxide only very slowly.

ILLUSTRATION DESIGN BY DESCRIPTION.

By PROFESSOR WILLIAM R. WARE.

This plate illustrates the paper upon the Teaching of Architectural History printed in the November number of the SCHOOL OF MINES QUARTERLY. The four drawings of Italian pilaster capitols, shown at the top of the page, were, as was explained in that paper, carefully described to a class of architectural students in the School of Mines, and the sketches that follow were made by them according to their own conceptions, without further recourse to the originals. This print is made from tracings of their sketches.

This paper will be followed in the April number by an illustrated article upon the Teaching of Architectural Drawing.

BOOK REVIEWS.

Reconnaissance of the Gold Fields of the Southern Appalachians. By GEO. F. BECKER. Extract of 85 pp. and several maps from the Sixteenth Annual Report of the Director of the U. S. Geological Survey, Part II., Mineral Resources of the United States, 1894.

The increasing interest in the gold resources of the South is manifested in the above valuable paper, as well as in the one by Mr. Nitze, whose review follows this one. The general thanks of mining and geological circles are due to the Director of the U. S. Geological Survey for detailing the most competent of American observers in the field of auriferous veins, and for the valuable and suggestive paper that has resulted. While the paper is chiefly occupied with Mr. Becker's personal observations in the South, it closes with a compilation regarding the eastern Canadian and Green Mountain areas, which offer many points of similarity, but for some reason not apparent no mention is made of gold in Virginia or Maryland.

Mr. Becker shows at the outset that the area under consideration contains three belts of productive country, viz: the *Georgian belt*, extending from Montgomery, Ala., through Dahlonega, Ga., to the 'Boilston Mine, just over the line in North Carolina; the *South Mountain belt*, in central North Carolina and including a group of mountains of this name; the *Carolinian belt*, far to the east of the latter, much wider and less defined. It extends southwest into South Carolina, and northeast two-thirds across North Carolina. The Virginia deposits lie on the same line further north. Charlotte, N. C., is near its middle point. The elevations are very moderate, and at most involve a range of low hills, which are called by the inhabitants the Uharie range.

The above outline is followed by a careful, historical sketch and by statistics. The latter give the output up to 1865 as follows:

	Md.	Va.	N. C.	S. C.	Ga.	Ala.	Tenn.	Total.
1799 thro' 1879	2,500	3,091,700	19,659,600	2,587,900	14,180,500	365,300	155,300	40,042,800
1880 thro' 1889	13,250	79,713	1,608,174	412,285	1,444,569	37,239	7,700	3,602,930
1890	16,962	6,496	126,397	100,294	101,318	2,170	1,001	354,638
1891	11,264	6,699	101,477	130,149	80,622	2,245	519	332,975
1892	1,000	5,002	90,196	123,881	95,251	2,419	1,006	318,755
1893	114	6,190	70,505	127,991	100,375	6,362	250	311,787
1894	978	7,643	52,927	98,763	99,095	4,092	329	263,827
Total	46,068	3,203,443	21,709,276	3,581,263	16,101,730	419,827	166,105	45,227,712

It is evident at once from the table that North Carolina has been the heaviest producer, with Georgia a good second and the rest scattering;

but that all have gradually declined in recent years, although Georgia and South Carolina have held their own better than North Carolina. The gold of the Georgian belt averages 0.950 in fineness, except at one mine, the Loud, which is 0.800. In the South Mountain belt it was in 1875 0.825. In the Carolinian belt it ranges over 0.900.

Dr. Becker next discusses the rocks, and shows that, while in the Georgian belt, the Ocoee formation of uncertain pre- or post-Cambrian sediments is represented, yet the principal rocks are Archean gneisses and schists. Gneisses and schists are chiefly present in the South Mountain belt, but the Carolinian is more complex. There is a strip of metamorphosed sediments with a plutonic area to the northwest and the Monroe beds of scarcely altered sediments on the southeast. The red Jura-trias sandstones are present in this quarter. There are also areas of pre-Cambrian volcanic rocks, now well recognized, although more or less silicified and otherwise altered, and there are intruded dikes of diabase and related basic types.

Garnetiferous schists occur in all the belts, and, curiously enough, the garnets are very generally auriferous. This discovery adds a most interesting fact to the mineralogical associations of gold.

In the Georgian belt the general strike of the schistosity is N.30–50E. and the dips are almost always 40° and more to the southeast. In the South Mountain area the strike is deflected to the northwest by some abnormal disturbance. In the Carolinian belt, while the strike is northeasterly, the dips are northwesterly 60° and more. The question of shearing and the development of schistosity are carefully discussed and the general conclusion is reached that the veins are in cracks, which were actual cavities, and which in the Georgian and South Carolinian belts run approximately parallel with the schistosity. In the South Mountain belts they cut it at a large angle and run in parallel series. In the Carolinian belt there are also impregnations of country rock, not always with visible quartz, but apparently along minutely fissured zones, so that the resulting deposit is a very good fahlband.

After perusal of the earlier literature it is refreshing to read the pages of an author who discriminates between bedding planes and schistosity from shearing. It is equally refreshing to find that the possibility of the derivation of schists from igneous rocks is also appreciated and that such change is actually shown in many cases. Without undue prejudice in favor of igneous originals or against sediments, it is certainly true that the former have received slight recognition in earlier work.

The mineralogy of the views receives careful treatment and aside from quartz and pyrites, a list is given of 45 minerals regarded as original gangue associates and of 14 which are considered secondary. We note native copper placed among the former, without comment, although it would appear to be on general principles a gossan mineral. After pyrites and quartz, chalcopyrite is much the commonest.

Dr. Becker regards the actual solvent that has brought the ores to the veins as an obscure point, for while alkaline carbonates and sulphides answer very well as carriers of the sulphides of arsenic, antimony, copper, zinc, and iron, they have so far as known but slight effect on the sulphide of lead, which is a not uncommon associate of the gold. The original source of the gold is still a subject for investigation. The gneisses suggest themselves with some claims to recognition, and igneous dikes of

granite or more basic rocks in instances have apparently exercised a favorable influence, but any very sweeping inferences have as yet slight foundations.

Under the head of "Placers" the superficial deposits are discussed. While stream gravels play a very minor rôle and merely deserve mention, yet the chief material is the surface layer of from 50 to 100 ft. of decomposed rocks containing stringers of quartz, native gold, etc., that is everywhere in this unglaciated region. Mr. Becker coins for it the new name "saprolite" from the Greek word for rotten, and uses it instead of the earlier and quite well understood term of laterite which has been generally applied by previous writers. If we believe the dictum that "use is the law of language" it is hardly clear that saprolite was needed even if laterite was originally applied in India to decomposition products in part transported. The amplification of the vocabulary of rock names, already unduly extended, and involved, lays such additional burdens on teachers and taught as to be avoided wherever possible, and a feeling of humanity should prompt the investigator to wrestle with the temptation until he has it safely under foot. Laterite has long been used, as a perusal of Zirkel's Lehrbuch, Vol. III, p. 772–774 will show, for decomposed surface rock with appropriate prefixes such as granitic, diabasic, gneissic, etc.

The recent history of this portion of the Atlantic coastal region, as shown by the relations of the drainage systems, is not overlooked by Mr. Becker, for it throws much light on the formation of the stream gravels, and it has been the subject of most interesting work in recent years. Local details of mines by belts occupy the next 24 pages, and are succeeded by a valuable bibliography. The last twelve or fifteen pages are devoted to the review of the deposits in the Maritime provinces and the Green Mountains.

The paper is very timely and will command wide interest. As an indication that the United States Geological Survey under Mr. Walcott, is to give more attention to regions important for their mineral wealth, and to describe them while the public attention is directed to them, it will be received with an even warmer welcome, and will be ranked with the Cripple Creek Atlas of Cross and Penrose, and will bring the survey many friends from among our mining engineers. J. F. K.

The Present Condition of Gold Mining in the Southern Appalachian States. By H. B. C. NITZE and H. A. J. WILKENS. A paper presented at the Atlanta meeting of the Am. Inst. Mining Engineers, October, 1895.

This paper is the result of an investigation made for the specific purpose of showing the economic status of the Southern Gold Fields and the present condition of the more prominent mines. It is particularly timely because of the recently awakened interest in gold mining. Although a considerable amount of geological information is given, classified according to the geography of the districts, the subject is treated mainly from a technical and practical point of view. At the outset the statement is made that the paper is intended to be, in some degree, supplementary to G. F. Becker's "Reconnaissance of the Gold Fields of the Southern Appalachians," published in the Sixteenth Annual Report of the Director of the U. S. Geol. Surv., 1894-5. The result of the study

made by Messrs. Nitze and Wilkens, comprised in the 135 pages, are valuable because of the thoroughness with which the work has been carried out, and the systematic arrangement of the details. These considerations, together with the conservative and judicial expression of opinion evident throughout the paper, are thought sufficient to warrant a rather extended notice, more in the nature of an abstract than of a review.

The following are the sub-headings of the subject matter: 1. Introductory. 2. Geopraphical and Geological description of the Gold Belts. 3. Historical. 4. Statistical. 5. General Distribution of the Mines, with notes. 6. Description of Mining, Milling and Metallurgical Practice at some of the Specially Characteristic Mines. 7. Conclusions.

The geological data, which are largely derived from reports and monographs, and are given in some detail, we may pass over with brief mention. The gold fields are situated in the area of the crystalline rocks, comprising gneisses, various schists and slates, limestone, granite, diorite, and diabase, with certain porphyries and breccias. They belong to the Archean, Algonkian and possibly, in part, Paleozoic ages. The rocks of the gold belt itself are decomposed to depths often reaching 50 and 100 feet. For such thoroughly decomposed, untransported material, Mr. Becker has proposed and used the name "saprolite" (meaning, "rotten rock"). Six districts, or belts, are recognized: those of Virginia, Eastern Carolina, Carolina (Central Piedmont), Western North Carolina, Georgia and Alabama. Brief descriptions of these are given.

Among the historical notes are some which show plainly the influence of the Southern methods of placer mining, and even of milling, upon the subsequent exploitation of the Western gold deposits. The first account of vein mining, in 1825, puts the pioneer work in Montgomery county, North Carolina. The treatment of concentrated sulphurets by roasting and amalgamation was introduced in 1856, near Rutherfordton, North Carolina. Hydraulicking seems to have been practiced previous to 1859, at Pilot Mountain, North Carolina. Wooden stamp mills (with iron shoes and dies) were used in Georgia as early as 1845. The stamps were similar to those of the present California mill, except that the stems were square, and the cams worked in slots or recesses cut in them. Some of these primitive mills are still in operation in the Nacoochee Valley, Georgia.

Under statistics it is shown that the southern states have occupied, among the producers of the precious metals, a more important place than is commonly supposed. From 1830 to 1894, inclusive, the production of gold and silver amounted to $45,047,798, nearly half of which has come from North Carolina, and more than one-third from Georgia. Previous to 1830 the recorded production was only $296,000. The total, as given, does not include bullion shipped abroad, or that which was used locally.

The most useful part of the paper is that which gives descriptions of the practice at some of the characteristic mines. At the Crawford Placer mine, Stanley Co., N. C., which was opened as recently as August, 1892, only coarse gold occurs, and large nuggets have been found. This deposit lies in a shallow depression averaging about 250 feet wide, and only 1½ to 2 feet deep in the middle. The auriferous material consists of angular fragments of quartz and country rock, in a

clay matrix. The bottom having insufficient grade to carry off the tailings, a washing tank and sluice were put up on the side hill at an elevation of about 30 feet above the creek. The deposit is mined by a system of parallel trenches 12 feet wide, and track is laid in these as they advance. After throwing off the upper 6 to 18 inches of the over-lay, the remaining 1½ to 2 feet, together with 6 to 12 inches of the bed-rock, are shovelled into cars, which are hoisted to the top of the washing plant. The tank is about 50 feet long, 18 feet wide and 6 feet high. On one of the sides there is a door or opening 4 feet wide, reaching to within 4 inches of the bottom. The grit is dumped into the tank and a constant stream of water is kept flowing over it. The action of this stream is reinforced by water from a hose nozzle under a head of 30 feet. Excepting at the time of clean-up, the tank is kept nearly full of gravel, and under the combined action of the two streams of water a very good concentration of the coarser nuggets takes place. The material, partially assisted with a rake, flows over a grizzly, and the coarser pebbles and boulders are forked off, while the finer gravel and sand are carried down into a sluice. The sluice is 400 feet long, 12 inches wide and 10 inches deep, and has an inclination of 6 inches in 10 feet. It contains only about 20 feet of riffles, and these are situated about 100 feet below the grizzly. The gold is seldom found below the first 4 or 5 feet of the riffles. The first hundred feet of the sluice aid in thoroughly washing and disintegrating the material before it reaches the riffles. No quicksilver is used, as there is no fine gold whatever. The cost of the work is about 50 cents per loose cubic yard.

The work being done by the Chestatee Co., Lumpkin Co., Ga., presents special features of interest, and might warrant a wider application in the South. The property comprises about 250 acres of placer ground on the banks of the river, together with about 1 mile of the stream bed. The main object in view is to turn the river into a new channel, which is at present being excavated, and ultimately to work the stream gravel as well as that in the adjacent bottoms. At the lower end the property a dam has been thrown across the river and a substantial and well constructed power station has been erected, supplying power for a pump and a 50 horse-power dynamo. A hydraulic elevator is used, which is supplied, together with the Giant, with water under 80 lbs. pressure by the pump. This direct appliance of pressure, without use of standpipe or reservoir, has here proved very successful, but it must be pointed out that pumps could not be profitably employed for very low-grade material.

The channel is cut 30 to 35 feet wide, down to bed-rock in depth, and will have a total length of about half a mile. When completed, the waters of the river will be turned into it by means of a wing dam. On the Chestatee River dredges have been in use for a number of years, but numerous shoals make dredging difficult, and failures are recorded oftener than successes. A plant now in operation consists of a 1¼ ton steam shovel, lying alongside of which is a barge carrying the sluices. There are two lines of sluice boxes, running the full length of the barge (100 ft.) and provided with longitudinal riffles. The gravel is discharged from the shovel on an iron-shod platform, at the head of the sluices, where the large stones are removed.

In the Dahlonega district of Georgia a peculiar method of mining and milling has been in use since 1868. It is adapted to the large bodies of

low-grade auriferous saprolite schists, which occur in the vicinity and elsewhere in the South, and consists in cutting down the soft decomposed ore bodies by means of a hydraulic giant, the water from which carries the material through a line of sluices to the mill situated some distance below the workings, usually on the banks of a stream from which it derives its water power. In the mill the coarser and heavier portions are retained by means of a screen, and are fed to the battery by hand, the mud and fine silt being carried through into the river. Generally, a third of the gold saved is caught in the riffles of the mine sluices, the remainder being obtained in the mill.

The material consists of soft, sandy mica-gneisses and schists, containing small and isolated quartz stringers, generally only a few inches thick. In a few cases lenticular auriferous and pyritic quartz bodies, 3 to 14 feet thick, have been found. In other parts of the Dahlonega region well-defined quartz veins occur, 3 to 6 feet thick. Enormous openings have been made in the gold-bearing saprolites by the hydraulic giants. Where harder rock is torn loose it is broken by sledges. Powder is occasionally used. To shorten the distance in sluicing to the mills, tunnels are often run through the intervening hills. A large proportion of the material going to the mills is barren, but cannot be separated by this method of mining. "The present practice is to flush the material on to the mill floor in back of the batteries. Frequently a V-shaped storage tank is situated outside of the mill, where the material is collected and flushed into the mill as occasion requires."

The statement is made that there are novel features in the Dahlonega stamp battery, both in the battery and in the setting. Similar practice, however, may be found in Colorado, excepting perhaps that the light Dahlonega stamp (450 pounds), does not require so deep a foundation. In not carrying the foundation down to solid rock consists the only essential difference.

"It is difficult to give any average values of the Dahlonega ores. Material worth as low as 40 cents per ton has been milled as a profit. If this figure per ton, plus the gold saved in the sluices (20 cents per ton milled) represents the milling value of 5 tons of material mined, as is stated to be frequently the case, then the value of the latter per ton must have been 12 cents. As a rule, however, the mill stuff is of better grade than the above. The actual ore (quartz) is stated to assay from $1 up to exceptionally high values in the cases of rich stringers or pockets. The cost of mining and milling throughout the district will average from 18 to 25 cents per ton of ore milled." "In hydraulicking, and subsequent transportation by water, a partial concentration takes place, resulting in the eventual deposition of a largely enriched product in the mill, the enriching being all the way from 2 to 5 times the original value of the ore in place. Besides this, free gold (generally about one-third of the total amount saved) is caught in the sluices before reaching the mill. Some of the losses in this process are evident from the above. Another serious loss, which is rapidly making itself felt as the mines grow deeper and less decomposed ores occur, is that of gold in the sulphurets. In such ores that carry sulphurets at all, it is stated that they will run from 2 to 10 per cent., the concentrates from which are reported to assay as high as $40 and higher. So far concentration has not been carried out on a working basis." The

only mine on the representative Dahlonega ore bodies where underground work of any importance is being done is the Lockhart. Here, quartz veins occupy the greater part of the gneiss bands, which in a mining sense may be termed the vein, and which occur in a country rock of biotite-hornblende-gneiss. The value of the ore varies from $1.00 to $4.00 or $5.00 per ton.

As examples of mines on well-defined fissure veins are cited the Reimer mine (Rowan Co., N. C.), and the Franklin (Cherokee Co., Ga.). The first is on a single, highly sulphureted quartz fissure of marked persistency, with smooth walls, and varying from 1½ to 9 feet thick. In the Franklin mine two veins are worked, in which four lenticular ore shoots have been opened within a horizontal distance of about 750 feet. Their average thickness is about 3 feet.

Probably the best known mine in the South is the Haile mine, South Carolina. It furnishes a good example of the development of large bodies of low-grade sulphureted ore. Silicious hydro-muscovite and argillaceous schist form the country rock. The ore bodies, lenticular in shape, are for the most part impregnations of auriferous pyrites and free gold. Striking across the formations are a number of diabase dikes, which, when they cut the ore bodies, appear sometimes to have an enriching effect upon them. In the better grade of ore the pyrites exists in a finely divided condition. Ore containing coarse sulphurets is generally of poor grade. The crucial test, however, of the value of the ore is the amount of free gold it contains, which is in direct proportion to that contained in the sulphurets, and is determined by panning. The ore at present delivered to the mill averages $4 per ton (assay value), of which about one-third is free gold. The percentage of sulphurets in the ore varies from 2 to 25 per cent.

These deposits are worked by the pillar system. The levels are run 70 to 100 feet apart, and at intervals up-raises are made which have an inclination of about 45°. The raises serve afterwards as "mill holes." Drifts are then run below the pillar under the raise to the end of the stope, leaving a vertical pillar 15 to 20 feet in thickness between the stopes. The ground is then cut away between the foot and hanging wall, completely exposing as roof the bottom of the chain pillar above, which is sprung in the shape of an arch, with its heavier toe in the foot wall and a minimum thickness of 15 feet. Stoping is then carried downward in circular steps, arranged in such a manner as to allow the ore to drop into the chute on blasting, without further handling. The angle of 45° given to the latter allows a steady flow of the material down the foot wall without completely choking it. As far as possible, the pillars are left in poor ore, the diabase dike fulfilling this purpose admirably. No timber whatever is used, and although chambers 100 by 100 by 40 feet have been cut out, there seems to be no danger of a fall, the country slate being very tough and self-supporting. The Haile mill contains sixty 750-pound stamps, dropping 6 inches, 86 times per minute. There are 20 Embrey tables, the product from which contains 90 per cent. pyrites, and carries from $25 to $35 per ton. Two double-hearth reverberatories and one revolving pan furnace are used for roasting the sulphurets, which are treated by chlorination. (See papers by W. B. Phillips, Trans. Am. Inst. M. E. XVII, 313, and XIX, 601.) Ores of as low grade as $2.75 per ton have been successfully milled.

Another representative Southern gold mine is the Brewer, Chesterfield Co., S. C., opened in 1828. The ore bodies are decomposed to the deepest workings, 150 feet, and average about $3.00 per ton. The sulphurets are finely divided pyrites, averaging about 7 per cent. of the ore. As it now exists, the mine is a large open pit, 150 feet in depth. There is a 40-stamp mill, with 900-pound stamps, which crush 5 to 6 tons per stamp per 24 hours. When the mine was visited the mill was shut down; and this is not surprising, because, having only 4 vanners to handle say 220 tons per day, the loss in tailings was so great as to leave little if any profit. The concentrates that were obtained ran from $15 to $20. The total cost of mining and milling (excluding chlorination) is $1.00 per ton.

In the last section of their paper Messrs. Nitze and Wilkens give a good general discussion of the conditions under which the Southern gold mines are worked. With the exception of a few rich pockets of limited extent, the ore bodies are low grade. There are but few mines, such as the Haile and the Franklin, which have developed into renumerative business enterprises. These have become successful under competent management, and ought to serve as examples for a larger number of operations, instead of being isolated cases, as at present. By far the greater part of the gold produced in the South has been derived from placer mining, much of it done in an unsystematic manner. There can be no doubt that large bodies of virgin placer and hydraulic ground still remain, and many old placers may warrant re-working on a large scale. In the Dahlonega district the saprolites have to a great extent been worked down to hard rock, and the peculiar method employed here, which aims more at economy in labor than close extraction, must ultimately reach its limit of application. The ore bodies, however, continue in depth and may open up a more productive field in deep mining. One drawback to the development of the Southern Gold Fields is that great numbers of properties are held at exorbitant prices, and satisfactory arrangements for examination, under option or otherwise, cannot be made, traditional merit and output being considered by the owners a sufficient proof of value. For the kind of deposits usually found in the South, mill tests are, in many cases, absolutely necessary for obtaining conclusive results. The most feasible propositions appear to be the working of large low-grade ore bodies, where systematic work on a large scale can be installed. Almost without exception a profitable extraction from Southern ores is attainable only by supplementing battery amalgamation by concentration, with subsequent treatment of the sulphurets. For treating the sulpurets some form of chlorination has been generally found satisfactory. Under favorable circumstances ores carrying only $3.00 per ton can be chlorinated at a profit. When the gold and sulphurets are so finely divided as to cause heavy loss in concentration, the cyanide process, or bromination, for direct treatment, might prove of value; or the ore might be treated in bulk by the modification of the Thies chlorination process used at Deadwood, Dak. It must be added, however, that attempts hitherto made with the Cyanide process have been unsuccessful, and the outcome of the Cyanide plant at the Russell Mine, N. C., will be watched with interest.

"Taken as a whole, the gold ores of the Southern Appalachians present no greater difficulties of treatment than those of other fields, the distin-

guishing feature being, perhaps, their large variety, which make a close study of each separate ore body necessary."

Attention is called to the fact that the so-called cheap skilled labor of the South is a misnomer. While unskilled labor is undoubtedly cheap, skilled workman command about the same wages as throughout the East. In districts where there is no active mining work, some trouble may be experienced in obtaining suitable labor. This excellent paper closes with the following sensible and conservative remarks:

"Gold mining in the South has its favorable features, which should facilitate the economic working of the ore deposits as legitimate business undertakings, with close and intelligent management. A considerable number of properties are at least worthy of investigation, and to the best of our belief, such investigations will disclose remunerative working opportunities, and will ultimately lead to a reasonable revival of gold mining in the South. Examinations would be greatly stimulated by more disinterested coöperation and reasonable demands of the mine owners, ultimately to their benefit." ROBERT PEELE.

Engineering Contracts and Specifications. By J. B. JOHNSON, C. E., Engineering News Pub. Co. 1895. Pp. vii+417.

A book of sufficient scope to treat completely the subjects of Engineering Contracts and Specifications would probably exceed the reasonable limits of any single volume. It is not to be supposed, therefore, that this work is exhaustive in its treatment of the subjects indicated in its title, although it covers in a compendious way the salient points of a civil engineer's experience in the writing of specifications and with the legal questions related to his work.

A careful perusal of that portion of the book (about one-fourth of its total matter) devoted to the law of engineering questions will be of much benefit to any engineer, but it will not make him his own lawyer. It is of essential importance for him to know that although the specifications for any given work may make him the sole referee, interpreter and arbiter "whose decision shall be final," yet he must exercise his powers in view of the fact that his decision will not necessarily stand as to matters within the jurisdiction of courts or which come under the provisions of the law. This is, of course, only common sense in its application to justice and equity; nevertheless, specifications are frequently so drawn as to violate the preceding simple principle. Again, the subject of liquidated damages and penalties is often treated by civil engineers in such a way as to indicate that they hold very erroneous views as to the real nature of the legal consequences of the nonfulfillment or breach of contracts, or of damages and penalties. The chief aspects of these and other portions of the law of contracts are well shown in Prof. Johnson's compilation. The competency of contracting parties, the nature and legality of agreements, the consideration, assignment of contracts, discharge of contracts, performance, etc., etc., are all given in sufficient fullness for ordinary purposes.

The second portion of the book comprising a large portion of Part II., together with Parts III. and IV., about three-fourths of the volume, embraces a collection of specifications and parts of specifications from various sources covering a great variety of engineering work. Specifications for earthwork, excavating and grading, cement, concrete and

masonry; streets, pavements and materials; sewers; water pipes; pumps; turbines; leather driving belts; installations for electric light and power, as well as a number of others required by the civil engineer in his general practice are admirably illustrated. Part IV. also containes "illustrated examples of complete contracts and specifications." The only unsatisfactory feature of this part of the work is the appearance in, at least, one place of a considerable portion of a set of specifications over the initials of one who is not the author of them. It is a small and unimportant point, but the error should not exist. As a whole the book cannot fail to be of much value to the engineering profession, especially since no work of the same scope has hitherto appeared. W. H. B.

Laboratory Manual of Inorganic Preparations. By H. T. VULTE, PH. D., F. C. S., and GEORGE M. S. NEUSTADT. New York, George Gottsberger Peck, 11 Murray St. 1895. 180 pp.

"Prepartions" in the line of organic chemistry have received much attention, and one can find many excellent books on the subject. Of books which perform the same service for inorganic chemistry, there are hardly any (practically none in the English language), apparently because the plan of instruction in this branch, which has usually been pursued, has not, in most cases, included this valuable form of instruction. The book before us is intended to supply such deficiency.

As intimated in the preface, it also affords suggestions as to various operations in applied chemistry, which are of great value in a system of chemical education.

The plan and conception of the work are excellent. Beginning naturally with the preparation of pure water and of other solvents, modes of preparation of the acids, alkalies, etc., and other reagents follow, and step by step the student is led to the management of operations quite complex in character.

In a work of this kind there would naturally occur to the authors the question as to what to omit among the multitude of materials which might be prepared by a student for purposes of instruction. On that point the individual bias of the teacher or the requirements of the pupils might lead an instructor to regard this particular work as too full or as not full enough. Another question might also be, how far back it is advisable to go in what constitutes the raw material or starting point for the manufacturing chemist, in order to lead up the products which can be worked up into the pure preparations, in order that the student may learn processes and reactions, and at the same time that the operations may be kept within the capabilities of an ordinary laboratory equipment.

These questions have evidently received careful attention from the authors, and no doubt in both of these lines the scope of the work will be extended in a future edition, which will assuredly be soon necessary.

That will also afford an opportunity for the correction of numerous typographical errors which it at present contains. Those errors are not, however, serious.

The descriptions given are clear, and the advantages in the use of the plan of instruction suggested by the work will commend themselves to all careful teachers. E. W.

Economic Mining. A Practical Handbook for the Miner, the Metallurgist and the Merchant. By C. G. WARNFORD LOCK. New York, Spon and Chamberlain, 12 Cortlandt Street. 1895. 668 pp. $5.00.

In the method of treatment adopted in this work the author has departed from the lines usually followed in writing books on mining and kindred subjects. He says, in the preface: "To promote condensation and facility of reference, and to avoid repetition, those operations which are common to all mining and metallurgy are first described, in general and comprehensive terms, and, as far as possible, in natural sequence. Next, the non-metalliferous minerals are taken in alphabetical order, a chapter being devoted to each and embracing all the practical information respecting their occurrence, working, extraction, preparation, qualities, uses, valuation and commerce, with details of specific processes and machinery employed." Finally, "similar treatment is given to the metals and their ores, in their turn, not omitting the metallurgical operations necessary for separating allied metals from each other."

Following this plan the first 119 pages are devoted to descriptions of the various operations connected with the opening and exploration of mines. These the author divides under the heads of Prospecting, Power, Drilling, Blasting, Shaft-Sinking, Ventilation, Lighting, Draining, Mining and Winning, Hauling and Hoisting. The succeeding 32 pages deal with Reduction and Concentration, and then follow 498 pages of matter comprising the mode of occurrence of the various minerals, and such special facts and figures relating to their extraction and treatment as are not included in the first part of the book. The text is supplemented by a good index of 15 pages.

It is not an easy matter to assign to this work its proper place in the literature of mining. It seems to us, after a careful examination, that the author is hardly justified in calling it a "practical handbook for the miner and metallurgist," as well as for "the merchant." As he has undertaken, in a single volume of moderate dimensions, to cover the occurrence and methods of mining of the entire range of minerals, it is evident that each individual mineral must be treated with extreme brevity. That such in the case is shown by the fact that only 26 pages are given to matter relating particularly to iron, 29 pages to coal and coke, less than 20 pages to gold and 28 pages to silver. Furthermore, the relative importance of the various minerals is not always observed as it should be in a work of this kind. For example, it may be asked, why, with due regard to the scale and scope of the subject matter, 50 pages should be given to copper and only 29 to iron. This chapter on copper, however, and the one on lead (40 pages), are among the most satisfactory in the book.

The special descriptions are, of course, to be considered in connection with those of the general operations of mining found in the first part of the work; nevertheless, in so extensive a field it is hardly possible to do more than touch upon the salient points. For this reason, we look upon the book as appealing first to the general reader and to the investor, who, as a business man, desires to inform himself as to the principles of the arts of mining and metallurgy. For all such the work is excellent and will serve a useful purpose; but the needs of the miner and metallurgist demand a detailed and technical treatment of the various operations of mining, in their relation to the useful minerals, and

from a professional standpoint, a book on mining, in so far as these details are lacking, must be considered as failing to accomplish its object. But, though we think the author has erred in the designation of his work, mistaking the class of readers amongst whom he will meet with most appreciation, we find in "Economic Mining" very much that is valuable. In its arrangement it is concise and logical, and we note with pleasure that the descriptions of antiquated and obsolete processes, which so often encumber bookson this subject, are entirely omitted. The descriptions are notably clear, and show unusual facility of saying a great deal in a few words.

This quality, and the broad field covered, serve to make the book almost encyclopædic in character. In some respects it really resembles more a cyclopædia than a handbook or treatise.

The information given is, as a rule, reliable and well up to date, and the wide experience of the author enables him to take his examples of practice from all the important mining regions. Some serious omissions are noticeable. For instance, although a number of references are of as late a date as 1894, indicating that the manuscript was not allowed to grow cold before being sent to press, yet the immense development of gold mining in South Africa receives but scanty attention, and the useful cyanide processes for the extraction of gold, one or two of which, in that and other regions, have of late been brought to a quite satisfactory degree of efficiency, are barely mentioned in the text, and do not appear at all in the index. Similarly, some of the later development of gold mining in the new camps of the western part of the United States is unnoticed. Many other omissions might be cited, but such imperfections must be expected in view of the excessively wide scope of the book. On the other hand, we think that, as a work on mining, its value would not have been lessened by omitting the chapters on a number of the non-metalliferous minerals.

The brief chapter on "Mining and Winning," which is more in the nature of a resumé of methods of exploitation than a description of the operations of mining, is a very good one, and the examples selected for illustration are well taken and clearly described. It is to be regretted that the author did not treat this important subject more fully. The same may be said of the chapter on "Concentration."

Of the illustrations we cannot speak highly; some are superfluous, while the really useful ones are far too few; the scale is usually small, the drawing often defective, and dimensions are rarely given. In illustrating descriptions of machinery and mechanical processes it is impossible to overestimate the value of good cuts, with the dimensions clearly marked. We think also that the value of the book would be enhanced if in addition to the foot-notes of reference (which, by the way, ought to be greatly increased in number), there had been appended to each chapter a short bibliography covering the subject matter. We would suggest to the publishers that to facilitate reference, the page headings—at least the right hand ones—should indicate the subjects dealt with.

The book is largely a compilation, much of the material having been drawn from monographs and technical periodicals, but criticism upon this ground is disarmed by the author's remark in the preface, that "in the preparation of such a volume * * * originality is to be looked for less in the facts recorded than in the method of marshalling them."

To a considerable class of readers "Economic Mining" will be useful, for between its covers is to be found a large amount of valuable, well-arranged information. R. P.

Chemical Technology, or Chemistry in its Applications to Arts and Manufactures. Edited by CHARLES EDWARD GROVES, F. R. S., and WILLIAM THORPE, B. Sc. Vol. II. *Lighting—Fats and Oils.* By W. Y. DENT. *Stearine Industry.* By J. MCARTHUR. *Candle Manufacture.* By L. FIELD and F. A. FIELD. *The Petroleum Industry, and Lamps.* By BOVERTON REDWOOD. *Miners' Safety Lamps.* By B. REDWOOD and D. A. LOUIS. Philadelphia. P. Blackiston, Son & Co., 1895. Price $4.00. Pp. 388. 8vo. Excellent typography and paper; good cloth binding; 358 illnstrations, mostly of large size.

This volume deals with the special application of Fuel to the purpose of producing light, irrespective of the heat developed.

Section I. is devoted to Oils and Fats, and deals only with those oils which are used for lighting. The subject-matter is ably handled by Mr. W. Y. Dent and discusses the description of fats and oils, methods of testing for purity, and the extraction and preparation of vegetable oils. In the section relating to the testing much has been done to render the tests precise and comparable when made by different observers, and in describing the method of extracting vegetable oils many large illustrations supplement the comprehensive descriptions of the modern machinery employed.

Section II. is devoted to stearine and discusses the raw materials employed and their valuation, the conversion of neutral fats into fatty acids by the three methods of saponification with lime or other base, with water alone and sulphuric acid, generally followed by distillation. Mr. J. McArthur gives a good popular description of the methods employed, which are well illustrated by drawings. These illustrations are mainly of the apparatus employed in the different methods of saponification, distillation and compression.

Section III. covers the manufacture of candles, and Messrs. L. and F. A. Field devote themselves principally to the modern machines for wick plaiting, dipping, drawing and moulding.

Section IV. The Petrolum Industry. Mr. Redwood has presented the subject in an interesting manner, discussing the origin, geographical and geological occurrence with maps, physical properties, and the chemistry of petroleum. The part devoted to drilling, transportation, storing and refining is well prepared. This section concludes with a description of the shale-oil industry and the refining and manufacture of paraffin.

Section V., also by Mr. Redwood, treats of lamps other than gas or electric, oil gas, air gas machines and carburettors.

The lamps are divided into two groups, those burning vegetable oils and those burning mineral oils. Numerous illustrations, many of them full page in size, set forth the special object of mechanical construction. The various burners, with special devices for lighting, trimming, adjusting and extinguishing, are fully discussed. The spray or blast lamps, so much used for night work in the open air, concludes this section.

Section VI., on safety lamps, is well handled by Messrs. B. Redwood

and D. A. Louis. The subject is treated in sufficient detail and with many illustrations.

While this work is neither strictly scientific nor strictly technical, it presents the subjects in a very popular manner, and the authors deserve great credit for the arrangement of material. Together with Vol. I. on Fuel and its applications (already published) and Vol. III., on gas and electric lighting (in preparation) this work forms the basis of a good popular understanding of the subject-matter treated. J. S.

ABSTRACTS.

ANALYTICAL CHEMISTRY.

By E. WALLER, PH. D.

Reduction Agent in Neutral Solutions. Aluminum Amalgam. Wislicenus and Kaufmann (Ber. XXVIII. 1323).

Oiled aluminium filings are treated with soda lye until it is strongly evolved. They are then washed once with water. Then an $HgCl_2$ solution of about 0.5 per cent. strength is allowed to act upon them for one to two minutes. The whole operation is then repeated to remove the blackish deposit which shows in the first. The material is then quickly rinsed off with water, with alcohol and with ether. If necessary it may be kept under petroleum ether. The last traces of water sometimes adhere with great persistence, and may be sufficient to cause the petroleum ether to boil. The material may be used to remove the last traces of H_2O from absolute alcohol or absolute ether, being entirely without action upon those compounds. It is capable of many applications in industrial work and in organic researches.

Cohen and Ormandy (Ber. XXVIII. 1505) claim priority in this field, having presented a paper on the subject before the British Association in 1889, and also in the J. Lond. Chem. Soc. 1890, p. 811, regarding its application in water analysis and for other purposes.

Neutral reducing agent. Magnesium amalgam. Fleck and Bassett. (J. Am. Chem. Soc. XVII. 789). A two per cent. Mg amalgam was prepared as follows: The required amount of mercury is placed in a small Hessian crucible, and half covered with Mg powder. The lid is put on loosely and the blast applied until a loud hissing noise begins. Once begun, the reaction takes place by itself. This is repeated until the requisite quantity of Mg. has been added. Results from the application of this agent are detailed.

Sodium Molybdenum Bronze. Stavenhogen and Engels. (Ber. XXVIII. 2280). By electrolytic action on fused Na_2MoO_4 with some MoO_3, using a current of 8.5 amp. 4.9 volts w=0.6 ohm. fine indigo needles were obtained, soluble in HNO_3 and in aqua regia as also in alkalies, but insoluble in HCl or H_2SO_4. The formula indicated by analysis would be $Na_2Mo_5O_{15}$.

Preparation of Pure Zinc. Mylius and Fromm. (Ber. XXVIII. 1563.)

The method of analysis pursued on specimens of so-called "pure zinc ore is described. Fusing the zinc, cooling to the crystallizing point

and separating the crystals, was found to be effective in separating Pt, and Cd, but had the opposite effect with Fe, the proportion of that metal steadily increasing with each successive melting.

Electrolytic separation of Zn from solution of $(NH_4)_2Zn(SO_4)_2,6H_2O$ (a very pure $ZnSO_4$ having been prepared for the purpose) gave, with Pb electrodes, a metal containing perceptible amounts of Pb. The best method was found to be the use of anodes of tolerably pure Zn in H_2SO_4. Care must be exercised to avoid too strong a current, too acid a solution, or a rapid evolution of gases from the decomposition of the water.

Hydrogen Peroxide for separations. Jannasch and Kaemerer. (Ber XXVIII. 1407) Twelfth paper. Separation of Mn from Ag. The H_2O_2 with excess of ammonia is added to the solution containing free HNO_3. After warming for about 10 minutes the precipitation of hydrated MnO_2 is complete. Wash first with ammonia containing H_2O_2, finally with hot water. Separation of Bi. from Co. The solution containing these metals is treated essentially in the same manner as just described. The precipitate contains a little Co, and must be redissolved on the filter with hot dilute HNO_3 (1:3) and re-precipitated in the same way as at first.

New Alkalimetric Indicator. "Luteol" Autenrieth. (Arch. Pharm. CCXXXIII. 43.) This substance, chlorohydroxy diphenyl-quinoxaline, is obtained from phenacetin. It is insoluble in water and but sparingly soluble in alcohol. It is useful in some cases where litmus or phenolphthalein cannot be used.

In acid liquids it is colorless, in alkaline solutions intense yellow.

Standardizing acid solutions. Perman and John. (Chem. News LXXI. 296.) A weighted quantity of borax will serve for standardizing acid if methyl orange is used as indicator, that substance being unaffected by the boric acid. Droop Richmond (ib. LXXII. 5) shows that the method is not new; also that for accurate work the proportion of water present in the crystallized salt must be determined accurately; also that the borax solution must not be too strong. 1 gm. in 20cc of water is a good proportion. The presence of much neutral salts must also be avoided. The methyl orange indicator may also need to be purified by one or two recrystallizations from alcolhol.

Taking B=10.95 1 gm. of anhydrous borax=0.48575 H_2SO_4 and 0.36115 gm. HCl.

Commercial Ammonium Sulphate. Hughes. (Chem. News, LXXII. 6.) The author finds that commercial $(NH_4)_2SO_4$ rapidly loses water by grinding in a mortar, so that a report as to free acid and moisture on a sample, after grinding up for analysis, is somewhat misleading. It is recommended that two water determinations (loss at 100° C) should be made, one on the unground sample, the other on the ground sample, the latter for the purpose of correcting the determinations of ammonia and acidity.

Sodium compounds in Lithium salts. Thompson. (Chemist and Druggist, XXXVI. 240.) The methods depends on the small solubility of NaCl in conc. HCl. To 10 gms. of the Li_2CO_3 in a flask, add 100 cc. of water, boil up, let cool, add water to restore the original volume, filter off 50 cc., evaporate this to dryness and treat the residue with 15 cc. conc. HCl saturated with NaCl, cool, filter, wash with 10 cc. of the same acid, then with pure HCl. Dissolve the residue in water, evaporate to dryness and weigh. The results agree with those obtained by the ether alcohol method.

Alkaline salts in Fire clays, Fertilizers, etc. Cameron. (J. S. C. I., XIV. 427). The results of a series of experiments show that long heating above dull redness of akaline carbonates or chlorides causes loss.

Dissolving out the alkaline salts, precipitating with $Ba(OH)_2$, etc., and subsequently weighing the mixed alkalies as sulphates carbonates or chlorides, led to the following conclusions:

1. The $Ba(OH)_2$ process is reliable, whether a moderate or a large excess of $Ba(OH)_2$ is added, or whether Mg is present or not.
2. The sulphate method is to be recommended on account of its simplicity, accuracy and rapidity.
3. The carbonate method may be used with equally good result.
4. The chloride method, on account of its troublesome nature and less trustworthy results, cannot be recommended.

Separation of Lime from Strontia or Baryta. Dupasquier. (Bull. Soc. Chin. XIII. 678.) The author has found that on boiling a solution containing lime and baryta or strontia after the addition of a solution containing 10 per cent. of $(NH_4)_2C_4H_4O_6$ and the same amount of $(NH_4)_2SO_4$, the *lime only* separates as tartrate, the others taking the form of sulphates. On obtaining the precipitate in this manner and washing with hot water to remove ammonium salts, the $CaC_4H_4O_6$ can be removed by washing with a little HCl. This solution should be kept separate from the tartrate solution. In these filtrates when Ba only was present besides the Ca, the latter can be precipitated by $(NH_4)_2C_2O_4$ and the precipitates united. If Sr was present, the tartrate solution will contain no appreciable quantities of Sr, but the HCl solution should be neutralized, allowed to stand and deposit $CaC_4H_4O_6$; in the filtrate the small amount of $SrSO_4$ retained is recovered by addition of a few drops of HCl, and two volumes of alcohol.

In case of a mixture of all three, a known amount of $(NH_4)_2SO_4$ should be added in the reagent and the amount of SO_3 remaining unprecipitated is determined. Weighing the combined $BaSO_4$ and $SrSO_4$ then gives the necessary data for calculating the proportions of those bases. This method is inapplicable when only small amounts of Ba and Sr are present.

Volumetric for Nickel, Moore. (*Chem. News*, LXXII. 92) (vid *Quarterly* X. 373. and XI. 70.) The author has endeavored to discover a sharp end reaction for the KCy titration. The end reaction here described depends upon these facts: In an ammoniacal solution of nickel containing suspended AgI, the solution will remain turbid so long as all of the Ni is not converted to K_2NiCy_4, but the least excess of KCy added thereafter will remove the turbidity. The amount of excess of KCy added may be determined by adding Ag solution until the turbidity is reproduced. If the titration of the Ni is conducted at a temperature below 20°C., the complicated reactions occurring in the KCy titration of Cu do not take place. The solutions necessary are: *$AgNO_3$ solution* containing about 3 gms. Ag per litre. The strength of this solution must be accurately known. *KI solution*, 10 per cent. *KCy solution* 22 to 25 gms. per litre. This requires to be standardized every few days.

First establish the relations between the $AgNO_3$ and KCy solutions. Dilute 3 or 4 cc. of the KCy with 150 cc. of water, add ammonia, then a few drops of KI, and titrate with $AgNO_3$, until the turbidity appears, removable only by a drop of KCy.

Now standardize the KCy against a solution of Ni containing a known amount of Ni (about 0.1 gm.) and enough free acid to prevent the appearance of a precipitate when it is just rendered distinctly ammoniacal (double nickel ammonium salt). Add a few drops of KI, dilute to 150 or 200 cc., then add a little $AgNO_3$, stir, and titrate with the KCy until the turbidity disappears. Determine how much excess of KCy has been added by adding the $AgNO_3$, stir and titrate with KCy until the turbidity disappears. Determine how much excess of KCy has been added by adding the $AgNO_3$ until the turbidity is just restored. Then deduct the amount of excess used, and the remainder of the KCy is to be calculated to its value in Ni. In this process Co is estimated with Ni; Mn, Cu, or Zn, interfere fatally. The influence of the last may be overcome by using an alkaline pyrophosphate solution. Presence of an excess of ammonia or a temperature above 20°C. are also bad.

Colorimetric Estimation of Titanium. Hildebrand. (J.Am. Chem. Soc. XVII. 718.) In using H_2O_2 for this purpose (vid QUARTERLY, XIII. 178) unsatisfactory results were obtained with a certain lot of H_2O_2 which was found to contain HF. Both HF and H_4SiF_6 were found to weaken the coloration even when present in very small quantities. The presence of this impurity is therefore of serious importance in this use of the reagent.

Titanic acid in iron ores. Wells and Mitchell. (J. Am. Chem. Soc. XVII. 878.) The pulverized ore is decomposed by heating with HCl for some hours, then the salts are converted to sulphates by addition of an excess of H_2SO_4 (1:1) and evaporating to fumes. After cooling, the solution is diluted to a definite volume, and aliquot portions are taken out. In one or more the Fe is reduced (in a flask) by saturating with H_2S covering the mouth of the flask with an inverted crucible cover, and after boiling out H_2S completely, diluting with cold water, and titrating with permanganate. In another flask both Fe and Ti are reduced by means of Zn rods suspended in the solution by platinum wire from the loop of the crucible cover inverted so as to make a protecting cover to the mouth of the flask. After boiling gently for 30 minutes, CO_2 is passed into the flask, to exclude air while the zinc is being removed and washed, the solution cooled and the titration with permanganate performed. The difference between the titrations gives the basis for the estimation of the Ti.Fe value divided by 0.7 gives value for TiO_2.

Copper and Copper Matte Assays. (Trans. Am. Inst. Min. Eng. Florida Meeting, March, 1895.) The results of assays, etc., by several different analysts on samples of the same copper matte, and on copper borings, are given, together with descriptions of the mode of management, etc. The results may be summarized:

ASSAYS.

Method.	Material.	Number of Analysts.	Highest. Ag. (oz.)	Au.	Lowest. Ag. (oz.)	Au.	Average. Ag. (oz.)	Au.
Direct Scorification, . . .	Matte	14	135.38	2.41	122.88	2.09	128.86	2.28
Crucible Assay, . . .	"	1					123 6	2.26
C'mb'n'd Wet and Sc'r'fic'n,	"	10	130.68	2.40	123.03	1.85	127.25	2.21
C'mbin'd Wet and Cr'cible,	"	1					126.20	2.09
Direct Scorification, . . .	Borings	10	164.35	0.40	147.40	0.30	158.16	0.35
C'mb'n'd Wet and Sc'r'fic'n,	"	16	161.40	0.501	148.50	0.205	156.48	0.28
C'mbin'd Wet and Cr'cible,	"	1					161.35	0.42

WET ANALYSIS.

	Material.	Number of Analyses.	Percentages (of Cu)		Average.
Electrolysis,	Matte	8	55.17	54.50	54.91
Cyanide,	"	6	54.80	50.55	52.815
Iodide,	"	1			55.00
(Not stated),	"	1			54.52
Electrolysis,	Borings	6	98.46	97.04	97.67
Cyanide,	"	1			97.98
(Not stated),	"	1			97.52

The details of manipulation communicated merit careful consideration. The "combination" method consists in general terms in dissolving (0.05 A. T. or more) in HNO_3, adding NaCl solution, then $Pb(C_2H_3O_2)_2$ followed by HSO_4—filtering and subjecting the precipitate to scorification or crucible assay.

Analysis of Galena. Jannasch and Kammerer. (Ber. XXVIII. 1409.) Moisten 0.70 to 0.75 gm. of the finely pulverized mineral in a porcelain dish with dilute HNO_3, allow it to stand for a few minutes in the cold, then add 10cc. conc. HNO_3 warm on the water bath and evaporate off. Now add HNO_3 and water again, and also 10 to 15 drops of Br and warm with frequent stirring until all S has been oxidized to sulphate.

In order certainly to destroy the bromate formed, evaporate three times with conc. HNO_3 to a dry powder. Then boil the last dry residue with 60 cc. of water and 20 cc. conc. HNO_3 for a short time to dissolve the $PbSO_4$. Filter hot to separate the siliceous gangue, and wash well with boiling water. Incinerate and weigh.

To precipitate the Pb, heat the filtrate to boiling over a naked flame until complete resolution has occurred, and then pour in a previously prepared mixture of 25 cc. H_2O, 50 cc. H_2O_2 and 50 cc. conc. NH_4OH. Pb separates as a beautiful yellow red powder partly crystalline. Its composition is yet to be determined. Allow to stand covered with frequent stirring for some hours, wash carefully with cold water, dry and weigh as PbO.

To determine the SO_3 in the filtrate from the Pb, it is necessary to evaporate on the water bath to disappearance of the odor of NH_3, then to add 5 cc. conc. HNO_3 and the same of alcohol, and heat quietly for some time to remove small amounts of persulphuric acid and H_2O_2, before precipitating with $BaCl_2$. If this proceeding is omitted the results will be too low.

Precipitating lead as sulphide. Mertens. (Pharm. Centrh. XXXIV. 273.) The solubility of PbS in HCl is increased by the presence of $CaCl_2$, and an acidulated solution containing both Pb and $CaCl_2$ may not readily show a reaction with H_2S.

Separation of Mercury from members of the Arsenic and Copper groups. Von Uslar. (Fres. Zts. f. Anal. Chem. XXXIV. 391.) The method of Polstorff and Bülow—dissolving HgS from the mixed sulphides by a mixture of K_2S and KOH, from which solution HgS free from As or Sb can be precipitated by NH_4Cl—is satisfactory except when Cd or Sn are present. Experiments were made as to the separation as Hg_2Cl_2 by phosphorous acid from these metals. Taking each one separately, Cu, Cd, As or Sb were perfectly separated whether in HCl or HNO_3 solution. With

Bi or Pb. the separation was impossible in HNO_3 solution, fair in HCl solution, the Hg_2Cl_2 always containing a little of the other chloride. With Sn the separation was not possible. Some HgO_2Cl_2 was dissolved by the Sn Cl_4. When all were mixed together, the separation from Bi was imperfect, and Sn, if present, rendered a correct result impossible.

Determining gold and silver in iron and steel. Warren. (Chem. News, LXXII, 100.) An account is given of a method pursued in a special case where such determination became necessary. Pieces of each of the samples weighing 4 pounds apiece were attached to the positive pole of a battery of 3 volts 40 amperes, and immersed in dilute H_2SO_4. A carbon was attached to the negative pole. The action of the battery was maintained until only a small fragment of the iron was left. The carboniferous residue, containing Au and Ag was then dried, mixed with litharge and reduced, cupelled and parted. Only traces of Au were found; Ag in the irons tested, was 0.055 to 0.8 per cent. of the carboniferous residue; in the steels 0.032 to 0.098 per cent. of the same.

Separation of Arsenic. Friedheim and Michaelis. (Ber. XXVIII. 1414.) A proposed modification of Fischer's method (distillation of As Cl_3 after reduction by means of $FeCl_2$.) Boiling with methyl alcohol saturated with HCl is found to reduce As_2O_5 and affords $AsCl_3$ when the vapors are conducted into water. The distillation begins at 40 to 50° and can be conducted over a water bath. A stream of HCl gas quite strong at first must be passed through the retort during the operation. The solution containing the As should be quite concentrated in order to avoid dilution of the methyl alcohol.

The distillation must be repeated two or three times to drive over all the As, and the cooling of the condenser tube requires careful attention as in the case of distillation with $FeCl_2$. Results are given showing the accuracy of this method as applied to mixtures of As_2O_5 with Vd, Mo and W salts.

Arsenic in steel, iron and iron ores. Stead. (J. S. C. I., XIV. 444.) A distillation method, followed by titration of the As_2O_3 with standard I. solution has been found expeditious and accurate. The standard solutions necessary are: *As_2O_3 solution* 0.66 gm. As_2O_3 dissolved by the acid of $NaHCO_3$, the solution when cold being made up to one liter (1 cc.=0.0005 As). *I. solution* 1.693 gm. I. and 5gms. KI in one litre. These solutions should correspond cc. for cc. The I. solution should be standardized occasionally by the As_2O_3 solution. A starch solution is, of course, necessary.

For steels place 1 to 50 gms. of drillings in a 32 oz. flask with enough HCl (1:1) to dissolve, attach to the mouth of the flask a safety tube and a Winkler gas absorption tube containing bromine water, with about 0.5 cc. Br in the bottom. Heat the flask to keep a steady current of gas passing through the Br water until no more H comes off. The gases from the Br should be passed into a small tube or flask containing KOH. (Solution of Ag_2SO_4 may be used instead of the Br water.) Unite the Br. water and KOH, which together usually contain about one-tenth of all the As, acidify with HCl, boil out Br, and add the colorless solution to that of the steel. At this point it may prove more expeditious to separate the As as sulphide, for which purpose drop into the flask about 0.5 gm. ZnS, agitate briskly for 3 minutes and filter. Dissolve the precipitate in Br water, warm to expel the Br, add HCl in a small retort,

also $FeCl_2$ and distil. By tipping the retort back, having a bend in the delivery neck, and slow distillation, the presence of Fe_2Cl_6 in the distillate can be prevented. Neutralize the distillate with ammonia, then add a few drops of HCl, then $NaHCO_3$ and titrate with the I. solution. With pig irons the separation as As_2S_3 is best omitted.

With ores distillation may be made at once with HCl and $FeCl_2$. If much MnO_2 is present, heat beforehand with HCl, and then distil with $FeCl_2$.

Titration of Arsenious Acid with Permanganate. Vanino. (Fres. Zts. Anal. Chem. XXXIV. 426.) A brown coloration resulting from only partial reduction of $K_2Mn_2O_8$ usually appears when titration is attempted in the cold. If the solution is warmed to 70°C and a considerable excess of H_2SO_4 is present, this difficulty is avoided, but the obtaining of the end reaction is tedious and somewhat uncertain. If, however, these last conditions are obtained, and an excess of $K_2Mn_2O_8$ solution is used, the excess can be sharply titrated back by use of a standard solution of H_2O_2.

Determining small amounts of Arsenic. Carnot. (C Rend. CXXI. 20.) The As is precipitated as sulphide—whether tri-or penta–makes no great difference. After filtering and washing this is dissolved through the filter with ammonia. Addition of $AgNO_3$ to this solution removes all the sulphide, affording silver arsenite or arsenate dissolved in the ammonia. After warming for a short time, a little H_2O_2 is added to insure conversion to arsenate. The solution is heated to 100° until the NH_3 is expelled, and it is then acidified with HNO_3, and a little HCl added to precipitate the Ag. Now, on filtering, AgCl and Ag_2S are separated and to the clear solution $Bi(NO_3)_3$ solution in excess is added. Then render alkaline with ammonia and boil for a few minutes. Filter off the mixed $BiAsO_4$ and $Bi(OH)_3$. Dissolve the precipitate in water containing one-fifteenth of its volume of HNO_3 of Sp Gr 1.31 and boil, when a heavy crystalline precipitate of $BiAsO_4$, H_2O will separate, which is filtered off through a tared filter, washed, first with acidulated water, finally with pure water, dried at 110° and weighed. The dried precipitate contains 21.067 per cent. As, or corresponds to 32.303 per cent. As_2O_3.

Analysis of Alloys containing Lead, Tin, Antimony and Arsenic, Andrews. (J. Am. Chem. Soc. XVII. 869). Half a gramme of the alloy (in the form of turnings) was weighed out in a porcelain boat, which was then placed inside a combustion tube. A current of HCl gas was passed through this tube which was heated at 210°C. The HCl gas was obtained by allowing strong fuming acid to flow through a capillary tube into conc. H_2SO_4. The gas was passed through a flask containing 10cc. of strong HNO_3 (Sp Gr 1.50) before entering the combustion tube. The exit of the combustion tube lead into a Volhard absorption flask charged with KBr, and kept cool during the process. In two hours the separation was complete, $PbCl_2$ being left in the boat and all the Sn, Sb and As being in the receiver. From this the As was separated by distillation, and in the remainder Sn and Sb were separated by Carnot's method—(boiling with an oxalate, $H_2C_2O_4$ and $Na_2S_2O_3$).

It was also found that boiling the alloy with HCl and KI effected the solution of all the constituents of the alloy alloy except the Sb, which could be filtered off, and after washing with boiling water converted to Sb_2S_3 and weighed. By the use of an argand gas burner, provided with

a hood or tent of asbestos and sheet iron over the top of the chimney, the temperatures required could be easily regulated.

Metals in fatty oils. Fresenius and Schattenfroh. (Fres. Zts. Anal. Chem. XXXIV. 381.) Three methods were tried for separating the metallic oxides so that they could be qualitatively tested or quantitatively determined. 1. Direct incineration. 2. Shaking the ether solution of the oil with dilute HNO_3 in a globe stop cock funnel tube, and drawing off the nitric acid solution of the metals. 3. Precipitation by H_2S. This latter was managed thus: A weighed amount of the oil is dissolved in about four times as much ether, a few drops of HCl are added, and then strong H_2S solution (in water). After vigorous shaking and then allowing to stand, the metallic sulphide will collect mainly at the junction of the two liquids. The most of the ether is poured off through a double filter wet down with ether. Then the filter is wetted with water, and the aqueous solution is filtered through. A small amount of oil and ether will remain on the filter, which can be removed by pouring ether once more through the filter. After washing with ether the sulphide may be ignited and weighed as oxide. The second method, extraction with dilute HNO_3 is the most convenient for large quantities and easiest of execution. All three methods were found to be efficient, especially in the case of Cu. In the case of Zn, care must be exercised in the first method, and when the second method is used it is advisable to evaporate twice or more with HNO_3 to destroy the organic matter which will go into the solution. In this case shaking with HCl instead of HNO_3, evaporating adding HgO and finally igniting (vid. QUARTERLY, XVI. 81) is satisfactory. The separation as ZnS is troublesome. It is more conveniently managed if chloroform is substituted for ether.

In the case of Al, methods 1 and 2 worked fairly well. Method 3 proved unpracticable, but precipation by ammonia, the operation being several times repeated, gave eventually correct results.

In the case of Pb, method 1 gave results too low from reduction and volatilization of the Pb. The other methods gave good results.

In the case of Fe, shaking with dilute HCl or HNO_3 (method 2) or precipitation by $(NH_4)_2S$ (method 3) gave good results.

Except in the case of Pb, method 1 (incineration) was used as the control method.

Electrolytic separations. Smith and Wallace. (J. Am. Chem. Soc. XVII. 612.) Experiments with cyanide solutions heated to 65° during the operation showed that the following separations could be easily effected in 3 to 3½ hours:

Hg from Cd, Zn, Ni and Co. Current ND_{100} 0.02 to 0.08 ampere unit.

Au from Co, As, Cu, Zn and Ni. Current, 0.1 ampere.

Ag from Zn, Ni and Co. Current, 0.04 ampere.

Electrolytic deposition of Ruthenium. Smith and Harris. (J. Am. Chem. Soc. XVII. 652.) The salt used was the double chloride of ruthenium and potassium. Deposition was effected; from a solution containing $NaC_2H_3O_2$. Current ND_{100}, = 0.01 to 0.05 amp. This afforded a black deposit, tending to be spongy. From a solution containing sodium phosphate and phosphoric acid and the same strength of current, a bright steel-like deposit was obtained. In a phosphate solution as above, it was found possible to separate Ru completely from Ir.

Purifying Glucinum salts. Hart. (J. Am. Chem. Soc. XVII. 604.) The best method was found to be: Fusing the powdered beryl with mixed carbonates, grinding and washing with water. The powdered mass is then treated with H_2SO_4 and evaporated to remove SiO_2. Then K_2SO_4 is added, and alum crystallized out, and again recrystallized. The Gl remains in the mother liquor. Oxidize the Fe with $KClO_3$, then add Na_2CO_3 little by little, boiling after each addition, until a filtered sample shows no yellow color. Then on boiling and filtering the whole, the Gl is retained in the filtrate, from which it can be separated by adding excess of Na_2CO_3.

Separating Iron from Glucinum. Atkinson and Smith. (J. Am. Chem. Soc. XVII. 688.) Nitroso B. naphthol (vid. QUARTERLY, X. 371 and XIV. 359) was found to be efficient. The solution containing about 0.125 gm. each of Fe (as ferric) and Gl, was diluted to 20 cc, the reagent added in the cold, and the mixture allowed to stand for 12 hours. On filtering, all the Fe was found to be in the precipitate, the Gl remaining completely in solution. The reagent does not precipitate cerous salts, lanthanum ammonium nitrate, praesodymium or neodymium nitrate, terbium, erbium or sodium molybdate or tungstate. It precipitates incompletely zirconium chloride (orange) and ceric ammonium nitrate (scarlet).

Separation of Uranium from Phosphoric and Arsenic Acids. Fresenius and Hintz. (Zts. Anal. Chem. XXXIV. 437.) Precipitation with ferrocyanide is effective, but the precipitate will not separate readily unless the solution is saturated with NaCl. Managed in this way the separation is satisfactory.

After filtering and washing with NaCl solution, the precipitate is treated cold with dilute KOH, digested a short time, washed once with water by decantation, then rinsed on the filter with water containing NH_4Cl and ammonia, and washed until all ferrocyanide is removed. Then dissolve in HCl, neutralize some of the excess of acid with ammonia, and add a moderate excess of $(NH_4)_2CO_3$, let stand some time for Fe to separate, filter and wash with very dilute $(NH_4)_2CO_3$, heat to expel the most of the $(NH_4)_2CO_3$, acidify with HCl and precipitate out what Cu may remain by H_2S. Concentrate the filtrate and separate U by ammonia, ignite to U_3O_8 and weigh.

Quantitative for Molybdenum. Friedheim and Euler. (Ber. XXVIII. 2061.) A review of the various methods proposed is given. A modification of the method of Mauro and Danesi (Fres. Zts. Anal. Chem. XX. 507) was found most satisfactory. This consists in heating the MoO_3 in a sealed tube to 100° in contact with HI and in an atmosphere of CO_2 when one or both of the following reactions occur.
$MoO_3 + 2HI = MoO_2I + I + H_2O$ or $MoO_3 + 2HI = Mo_2O_5 + H_2O + I_2$. In either case each molecule of MoO_3 liberates one atom of I which is titrated with standard $Na_2S_2O_3$ solution.

The modification consists in heating the solution containing MoO_3 in a Bunsen apparatus with KI and HCl (Sp Gr 1.12), distilling the I over into KI and titrating. An especial point is made that the heat must be applied with care at first and the solution not brought to boiling until the delivery tube is completely filled with fumes of iodine or the oxygen of the air remaining in the apparatus will react with the HI and give results too high.

Determination of Molybdenum and Vanadium. Friedheim and Euler. (Ber. XXVIII. 2067.) In a solution containing both a molybdate and a vanadate both may be determined by the following method:

Decompose the compounds in a Bunsen apparatus by means of fuming HCl and KBr, distilling into KI. A titration with twentieth normal $Na_2S_2O_3$ will then give the means of calculating V_2O_5 present, then add 1 gm. solid KI and 1 to 2 cc. syrupy phosphoric acid and distil again, catching the I evolved in other KI for titration as before. From the number of cc. used in the last titration, deduct the amount used in the first case and the remainder is calculated to MoO_3. The reaction with the V_2O_5 takes place in two stages, the KBr distillation bringing it only to V_2O_4, the subsequent KI distillation affording V_2O_3. The MoO_3 is only affected by the KI distillation.

Determining Tungsten. Cremer. (Eng. and Min. J. LIX. 345.) Fuse 0.5 gm. of the pulverized ore with 6 gms. $K_2S_2O_7$ in a porcelain crucible, the heat being slowly increased to the highest attainable, at which it is maintained for half an hour. Cool, and boil the cake in dilute HCl (1:2.5). The WO_3 remains in suspension. Dilute considerably, and boil. Add a few cc. of a concentrated solution of cinchonine in HCl, and then after boiling a few minutes longer the (yellow) precipitate is allowed to settle partly, and is then filtered, washed with very dilute cinchonine solution, ignited and weighed as WO_3 with SiO_2. The WO_3 is dissolved out by boiling ammonia, and the SiO_2 filtered off and weighted again. Ferrotungstens are treated in a similar manner.

Determining selenious acid by potassium permanganate. Gooch and Clemons. (Zts. Anorg. Chem. IX. 360.) The temperature at which the reaction is conducted, was found to have a decided influence. The plan recommended is to add an excess of tenth normal permanganate to the selenious solution which contains at most 5 per cent. of its volume of H_2SO_4. Then clear by addition of normal oxalic acid, and finally titrate back the excess of oxalic acid with permanganate at a temperature of not over 50 to 60°C.

Separating Tellurium from Copper. Whitehead. (J. Am. Chem. Soc. XVII. 849.) On adding to the solution an excess of NaOH and then KCy in the proportion of about 3 gms. to every gramme of Cu present, and subjecting to electrolysis with a current of the strength ordinarily used in precipitating Cu, in 12 hours, all Te is thrown down as a black precipitate which can be filtered off and weighed. Then on acidifying the solution with H_2SO_4 the Cu can be precipitated by the same current in the usual manner.

Halogens in Organic Compounds. Küster. (Liebig, Ann. CCLXXXV. 340.) Certain details of manipulation are recommended in the Carius method, and the author also asserts that the use of a known amount of $AgNO_3$ and titration of the excess of Ag remaining in solution is inaccurate. Such has been recommended by Walker and Henderson (vid. QUARTERLY, XVI. 290.) Küster finds that the glass of the tube takes up Ag. After the heating the glass may contain 3.8 or more of Ag. A soft glass, pulverized and subjected to the ordinary conditions obtained in conducting the method, was found to have taken up 15.8 per cent. of Ag.

Walker and Henderson reply to this criticism (Chem. News, LXXI.

295) to the effect that no such error is introduced if the heat of the tube is not carried above 280 to 300° C.

Determination of Halogens in mixtures of their silver salts. Gooch and Fairbanks. (Zts. Anorg. Chem. IX. 349.) Experiments were made as to the separation of the Ag. Dissolving in KCy and applying electrolysis affords nothing accurate. Electrolytic reduction of the material in presence of H_2SO_4 is unsatisfactory on account of the difficulty in washing the H_2SO_4 completely out of the spongy Ag. Some of the halogens are also set free and attack the platinum of the crucible in which the material is held, or which forms the electrode. The use of a 25 per cent. alcohol containing one-tenth its weight of oxalic acid was found to be free from these objections, when AgI is not present. In presence of AgI a solution was used consisting of 2 vols. of 40 per cent. $HC_2H_3O_2$ neutralized with ammonia, 1 vol. ammonia, 1 vol. aldehyd and 1 vol. alcohol. With this at times crusts of NH_4IO_3 formed on the anode, which were readily removed by dipping the anode momentarily into hot water If not dissolved off, these crusts interposed too strong a resistance to the current. Repeated filtering to secure all of the particles of metallic silver was also necessary in this case.

Chlorate in Bleaching Powder. Fresenius. (Zts. Anal. Chem. XXXIV. 434.) Pattinson's method, essentially that described by Norton (J. Anal. App. Chem. VI. 274) is unsatisfactory, the chloride being determined by the difference between total Cl after converting it chloride, and Cl as chloride after treatment calculated to convert all Cl. to chloride *except* that present as chlorate. The method recommended is treating a known amount of the material with $Pb(C_2H_3O_2)_2$ solution which affords PbO_2 and Cl. By standing from 8 to 10 hours the free Cl. disappears partly by escape into the air, partly by reacting upon the excess of Pb salt to give more PbO_2. The precipitate should be filtered off and washed so long as the washings are acid, and the solution, concentrated if necessary, is precipitated by Na_2CO_3. In the filtrate, the chlorate can be determined by Bunsen's method, heating with conc. H_2SO_4 conducting the gases evolved into KI solution and then titrating with $Na_2S_2O_3$.

New Reagent for Bromine and Iodine. Kastle. (Am. Chem. J. XVII. 704.) The reagent is a dichlor derivative of benzene sulphonamide. It sets Br or I free in the same manner as Cl water does, but has the advantage of not being altered or rendered inefficient by exposure to light, etc. It is prepared by dissolving benzene sulphonamide in the smallest possible amount of 1:10 solution of NaOH and passing in a rapid current of Cl. The first portions of precipitate which appear consist chiefly of unchanged amide. This should be filtered out and the filtrate again treated with the gas. The second precipitate consists chiefly of the dichlor derivative. It is insoluble in water, even when hot, and melts at 70°, so that it can be purified by heating with water, under which conditions it separates as a light yellow oil. It may be further precipitated by dissolving in absolute alcohol and precipitating by adding water. It may be used as a reagent either in the solid state or in solution in CS_2. The latter is usually preferable. Too large a proportion will afford colorless ICl, etc., as in the case of Cl water.

Determination of Fluorine. Jannasch and Röttgen (Zts. Anorg Chem. IX. 267). The element is expelled from its combination by heating the material in a specially constructed platinum retort at 155 to 160°C,

together with conc. H_2SO_4, a current of CO_2 being passed through the apparatus. The HF and CO_2 are caught in a strong solution of NaOH. The solution is afterward precipitated with $CaCl_2$ solution, the mixed CaF_2 and $CaCO_3$ filtered off, washed and ignited and then the $CaCO_3$ dissolved out by means of a very slight excess of acetic acid, the CaF_2 washed, etc., and weighed.

Phosphorus in Steel. Thackray. (Am. Inst. Min. Eng. Atlanta meeting, Oct., 1895.) In consequence of a disagreement in results between the buyer's and seller's chemists regarding the per cent. of P in a certain lot of steel, two samples were prepared and submitted to different chemists for analysis. The results, as well as the methods employed, are given. 36 determinations on each sample from 23 different laboratories show as follows:

	Highest	Lowest	Average
Per cent. of P	0.055	0.045	0.0496
" " " "	0.091	0.076	0.0835

For the details of the manipulations, which in many cases differ but slightly, the original paper must be consulted.

Phosphoric acid. Hanamann. (Chem. Ztg. XIX. No. 25.)

Using a reagent containing 100 gms. MoO_3, 1 litre of 10 per cent ammonia and 1½ litres HNO_3 (Sp. Gr. 1.246), complete precipitation can be effected in the cold by vigorous stirring for 30 minutes. After filtering and washing, heating the precipitate to just below redness until it becomes of a uniform blue-black color, a material is left containing 4.018 per cent. of P_2O_5.

Phosphorus in titaniferous ores, etc. Pattinson. (J. S. C. I., XIV. 443.) TiO_2 will form a ferric phosphotitanate only partially soluble in HCl when the ores are treated with that acid. In the insoluble the SiO_2 must be expelled by use of HF (and H_2SO_4) and the residue fused with Na_2CO_3 from which Na_3PO_4 can be extracted with water. The presence of TiO_2 prevents precipitation of P_2O_5 by molybdate solution. The TiO_2 can be removed by reducing the most of the Fe, then separating P_2O_5 and TiO_2 by precipitation of ferric phosphate (carrying with it TiO_2) and fusing this precipitate with Na_2CO_3 as before. Stead reduces all the Fe to ferrous and then adds alum and precipitates $Al_2(PO_4)_2$ from which the P_2O_5 can more readily be extracted by water after one fusion, wheras the $Fe_2(PO_4)_2$ may require two or three fusions to effect a complete separation.

Phospho Molybdate precipitate. (Yellow precipitate.) Blair and Whitfield. (J. Am. Chem. Soc. XVII. 747.) In connection with the work of the International Standards Committee, ten different samples of the "yellow precipitate" were prepared, the conditions of preparation being varied with each. The methods of analysis are described. The results gave the average ratio of P to 100 MoO_3, =1.7946 and agreed fairly with the formula $24MoO_3$, 2 $(NH_4)_3PO_4$, x H_2O, x in one case being 2, in another 22, the difference being due to the temperature at which the salt was dried—below 150° or up to 250°. Hundeshagen's assertion (vid. QUARTERLY, X. 377) that the salt when dried in a dessicator contains HNO_3 or some of the acid of the solution in combination, could not be confirmed.

In passing solutions of the "yellow precipitate" through the reductor,

it was found necessary to follow the solutions with dilute H_2SO_4 to avoid leaving some green Mo oxide on the Zinc.

It was also found necessary to have the solutions sufficiently concentrated, viz, a volume of about 100 cc. for weights of phospho molybdate up to 0.2 gm.

The reduction appeared to be to $Mo_{24}O_{37}$.

The conclusion cautiously expressed is that the ratio of P to MoO_3 is 1.794, and that the value of MoO_3 is compared with Fe for the $K_2M_2O_8$ solution is 0.88163.

Incidentally it was found that the yellow precipitate which forms in molybdate solutions on standing, is a hydrated form of MoO_3.

Sulphur in refined Copper. Heath. (J. Am. Chem. Soc. XVII. 814.) If the Cu is allowed to remain in the solution, $CuCl_2$ appears to retard the precipitation, especially when strongly acidified.

With refined coppers, etc., low in S, take up to 10 gms. of the sample dissolve in a large beaker over an alcohol flame in 60 cc. conc. HNO_3 and 15 cc. conc. HCl. Evaporate nearly to dryness, then add 50 cc. strong HNO_3 and evaporate again. Repeat. Redissolve in 300 cc. of water, filter and bring to 600 cc. or more. Precipitate the most or all of the Cu by electrolysis, decant, add about 0.1 gm. Na_2CO_3, evaporate rapidly in a casserole, heat to volatilize NH_4NO_3, cool, add 10 cc. conc. HCl and 5 cc. of water, and evaporate to dryness on the water bath. Repeat, and then add 50 cc. water and 1 cc. HCl, dissolve, filter and wash.

Heat to boiling, precipitate with a slight excess of $BaCl_2$, let stand 24 hours, filter, etc., as usual. The precipitation can be hastened by keeping the liquid at 75°C or over. An alcohol lamp had best be used as the source of heat throughout.

Sulphurs in Irons, etc. Campredon. (C. Rend, CXX. 1051.) The metal is attacked by H_2SO_4 1:5 or HCl 1:3 in a flask into which is passed both CO_2 and H_2. The gases are then passed through a porcelain tube heated to orange redness or above, and then through a slightly acid solution of Zn $(C_2H_3O_2)_2$ in which the S precipitates as ZnS. To this is then added a measured excess of standard I solution, and after standing a few minutes the excess of I is titrated back by standard NaS_2O_3 solution.

Qualitative examination for sulphide, thiosulphate, sulphide and sulphate in presence of each other. Bloxam. (Chem. News, LXXII. 63.) Addition of a mixture of $ZnCl_2$, $CdCl_2$, NH_4Cl and ammonia in a stoppered flask, and frequent shaking, removed the sulphides from the solution. In the filtrate sulphite was detected by nitro-prusside, red color, or if very faint the reaction was brought out by addition of a few drops of ferrocyanide.

For sulphate some of the solution was boiled in a flask after addition of $NaHCO_3$ and CO_2 gas was passed through. After it had been brought to a boil, HCl (free from Cl) was run in through a stopcock funnel tube, and the boiling and passage of CO_2 maintained until H_2S, SO_2, etc., had been expelled. On filtering, the solution was tested for H_2SO_4 by $BaCl_2$.

Analysis of Silicon. Vigoroux. (C. Rend, CXX. 554.) Use about 0.2 gm. for each determination, heating for a few minutes to redness, in order to have material absolutely dry.

SiO_2: Weigh out in a tared boat, place the boat in a Bohemian glass tube, and heat in a current of dry Cl At about 450° the Si takes fire,

and volatilizes as chloride, leaving SiO_2. A somewhat higher temperature is necessary to decompose silicides. Expel the Cl by a current of H before opening the tube. Finally weigh residual SiO_2.

Si: Boil a weighed portion of the finely pulverized sample for a considerable time in strong solution of K_2CO_3, Si and SiO_2 are dissolved. Washing and weighing the residue gives foreign material and Si with SiO_2 by difference.

Metals: Treat a weighed quantity in a platinum capsule with HNO_3 and HF both free from Cl. Then add concentrated H_2SO_4 drop by drop, until it is present in decided excess. Evaporate on a sand bath to obtain the metals as sulphates when they may be determined by known methods.

Graphite in Pig Iron. Shimer. (Am. Inst. Min. Eng. Atlanta Meeting, October, 1895.) On dissolving pig iron in HCl, or in H_2SO_4 insoluble titanium carbide (TiC vid. Am. Inst. Min. Eng. XV. 455) is left with the graphitic carbon, and being also insoluble in the KOH, alcohol, etc., used for washing the carbon therein, is reckoned as graphitic. As the combined carbon is usually taken as the difference between total carbon and graphitic, the error extends also to combined carbon. Experiments quoted tend to show that solution of the iron in HNO_3 breaks up the TiC, which accounts for lower results on graphitic carbon with that solvent, which have hitherto been attributed to the oxidizing action of the HNO_3.

Titration of Cyanides. Clennell. (Chem. News, LXXI. 274.) In solutions used for extraction of Au by the cyanide process, the ordinary $AgNO_3$ titration gives indefinite and erroneous results. If the solution contains no alkaline double cyanides, the addition of $Ca(OH)_2$ and filtering will give good results with $AgNO_3$.

The I titration (Fordos and Gelis) (see Sutton Vol. Anal., 7th Ed., p. 175) gives fairly accurate results if no caustic alkalies or monocarbonates are present. The reaction is $KCy + I_2 = KI + ICy$, the end reaction being determined by starch. It was found that accurate results could be obtained by first adding to a measured quantity of the solution $AgNO_3$ until a distinct turbidity was obtained. Then $N/_{10}HCl$ is added from a burette after addion of phenol plethalein until it is just decolorized. This gives the amount of alkalinity which must be neutralized before the I titration will afford correct results. Then to another measured amount of the solution add a *little less* $N/_{10}HCl$ than that indicated, and then titration with I solution will give correct results.

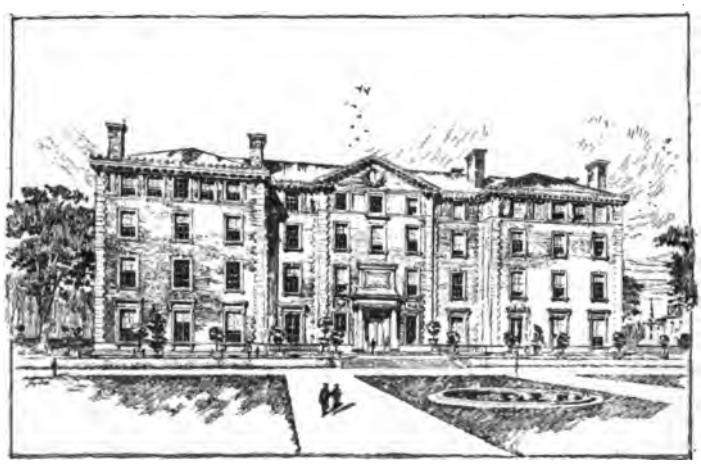
Another method consists in decomposing the double cyanides by H_2S. Render the solution decidedly alkaline by KOH or NaOH, shake well and filter. Remove the excess of sulphide by agitating with litharge in small quantities at a time until it gives no precipitate with a drop of Pb solution. Then filter and titrate with standard $AgNO_3$.

Reagents for Hydrogen Peroxide. Ilosvay. (Ber. XXVIII. 2029.) Several deviatives of aniline were tried, the most sensitive being found to be dimethylanilin. Five drops of this were added to one litre of water in which was dissolved 0.03 gm. $K_2Cr_2O_7$. 5 cc. of this solution on being mixed with the solution to be tested, and the mixture acidified with one drop of 5 per cent. $H_2C_2O_4$ gave a yellow coloration in one minute when one part of H_2O_2 in 5 million was present. The reaction is not, however, absolutely characteristic for H_2O_2 as distinguished from ozone.

BULLETIN OF ALUMNI AND COLLEGE NEWS.

SCHERMERHORN HALL.

As the Trustees have authorized the construction of Schermerhorn Hall and the "Physics" building, so far as yet named, and as no small part of the instruction in courses given in the School of Mines will be done in them in the future, the readers of the QUARTERLY will be interested in the accompanying cuts from the architect's drawings and in the appended descriptions. Reference to the map on page 81 of the last issue of the QUARTERLY will show the situation of the two at the north-eastern corner of the grounds. Schermerhorn Hall is the one there called "Natural Science," and the Physics building is the one called the School of Arts. It is also of interest to note that the Engineering de-



SCHERMERHORN HALL
COLUMBIA COLLEGE N.Y.

partments, viz., Mining, Civil Engineering, Mechanical Engineering and Electrical Engineering, have been assigned to the building on the north-east, called "Chemistry," while Chemistry, Metallurgy and Architecture have been placed in the one there called "Engineering." The School of Arts has now been assigned to the southeast corner and will appropriately stand at the right of the main entrance, suggesting thus by its post of honor the source from which all the others have been developed.

Schermerhorn Hall consists of two wings, connected by a central portion, which has also a projecting, two-storied extension on the north side. Those who have visited the new site will recall the high retaining wall which now extends east and west across the northern central portion. This will run against the west foundation of Schermerhorn Hall, somewhat north of the middle point of the west wing. On the south of the building the ground level is nearly flush with the floor of the

second story, but on the north the first floor has full illumination, although dark, except for windows opening into areas on the south. The windows on the north are, however, of great size and are expected to afford abundant light. It is to be regretted that we have no view of this side to present, but no drawing has been made. In some respects it is the most impressive side of the building. The first floor has a ceiling twenty-five feet high. The second floor is eighteen feet, the third fifteen and one-half, the fourth fifteen, and the fifth fourteen. The wings are 50 feet wide, by 75 feet long inside, the central portion is 95 feet by 70 feet, and the projecting extension is a rectangle 6 feet by 70 feet, which is continued in a semi-circle of 35 feet radius. The building will contain the departments of Mineralogy, Geology, Experimental Psychology, Botany and Biology as at present organized.

Mineralogy. To the department of Mineralogy the first and second floors of the east wing and portions of the main building on the same floors have been assigned. The first floor in the wing will contain the large laboratory and lecture room. It will receive light from the north end, from the east through three windows on the street and through small windows near the ceiling on the south. Off of this and in the main portion small and dark rooms will be located for work with the reflecting goniometer, and with apparatus for the study of the optical properties of minerals. The south side of this main portion is divided into mezzanine floors, which afford the necessary space for these and for toilet rooms. An office is also provided on the south side. The large room in the east wing, on the second floor, will be used as a mineralogical museum, and a gallery will be run along its western side. Three smaller rooms on this floor supply offices and library. A large annular space beneath the seats of the large lecture room, with many windows hava north light, has also been assigned to this department for microscopic work.

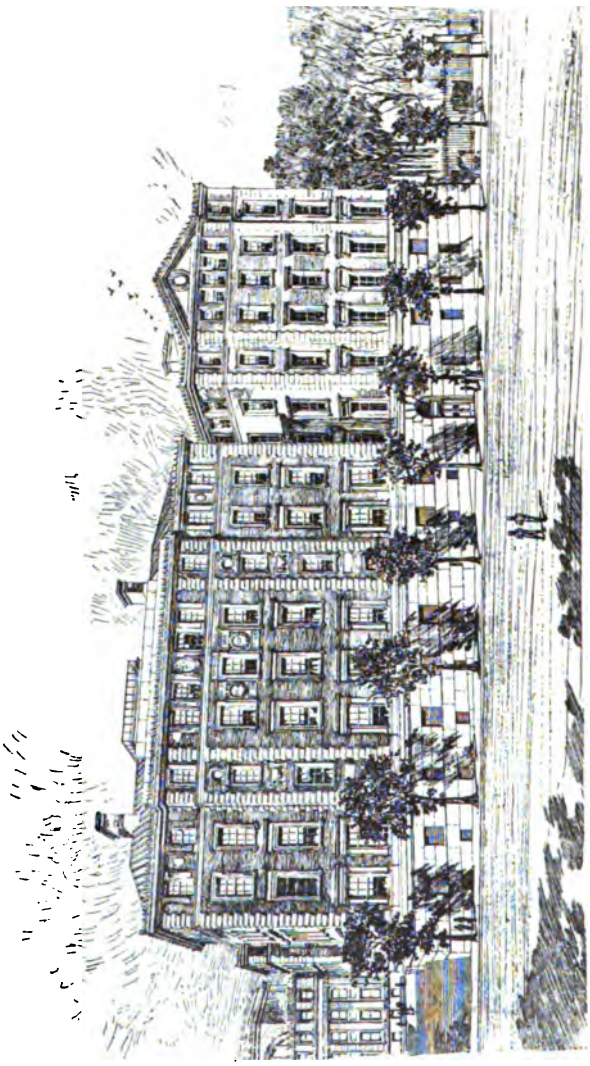
Geology. The space assigned to this department has been divided up in appreciation of its present threefold nature, for geology proper, physical geography or physiography and paleontology are all at present comprehended in it. When the inevitable separation comes the several parts will be in a measure in their own quarters. The museum of paleontology is to located on the first floor in the extension to the north. In a gallery on the north side will be displayed the collections in paleobotany. The wing room will be devoted to a laboratory for paleontology, to a laboratory for rock analysis, rock-section grinding, dark room for photography, and on the south end storage room for incoming collections and other materials for the geological and biological departments.

On the second floor the west wing room will be used as a museum in economic and physical geology as distinguished from paleontology. It is the plan to display here also relief maps and geographical models such as will be used in future instruction in geography. An office and a seminary room adjoin the museum.

On this floor it may also be remarked parenthetically are the main entrance, reception room, hallways and the large public lecture room to which reference will be made later.

In the west wing of the third floor will be located the geological lecture room and main laboratory for rock study and regular class work. A professor's office and departmental library and seminary room adjoin it.

Experimental Psychology is to occupy the eastern half of this floor. The space is to be subdivided so as to afford a lecture room, suitable offices, small rooms, dark and light, so isolated as to give perfect quiet and favorable conditions for experimental research in psychological phenomena.



VIEW FROM AMSTERDAM AVENUE OF PHYSICS BUILDING AND SCHERMERHORN HALL

Botany. The fourth floor has been assigned to the department of botany. The east wing is to contain the morphological laboratory, the herbarium and the general botanical museum. The north side of the main building contains a central library, with a lecture room on the west

and a curator's room on the east. The north side has three rooms called as yet "professor's rooms." The west wing is devoted to a general elementary laboratory, from which is partitioned off on the northeast corner a physiological laboratory and in the southeast a conservatory. There is some probability that the advanced graduate work will in part at least be done in the new botanical garden in Bronx Park.

[NOTE.—Since the above was written an agreement has been reached between the Trustees of the College and the Managers of the New York Botanical Garden, whereby the Hebarium and Botanical Library are to be located in the laboratory of the Garden. The graduate work will hereafter be done there.]

Biology receives the fifth floor. The east wing is divided so that there will be on its north side a large laboratory devoted to Junior and Senior work. On its south side is a lecture room and a neurological laboratory. The main building has on its north side nine small offices and laboratories; on its south side, at the east, a room for the preparator and for charts; in the center, the departmental library and reading room, and on the west an experimental biological laboratory with aquaria. The west wing has a laboratory on the north for second-year graduate students, in the centre a large one for first year graduates, and on the south a professor's office and two small laboratories, of which one is devoted to comparative osteology. Above is an attic space over the entire story. It is provided with ventilating fans, etc.

General. The main entrance to the building is on the south side at the level of the second floor. A large hallway or corridor seventy feet deep faces the door and leads into one running east and west to the wings. Opposite the door is the central lecture room, which will answer for moderately large gatherings as it is designed to hold about 300 people. The lecture desk is on the south, and the entrances are on either side of it. The seats rise concentrically outward in tiers, leaving beneath them near the windows the annular room assigned to the department of Mineralogy.

In front of the lecture room diverging stairways lead to a landing on the mezzanine floor and then converge for the museum and laboratories below. Lavatories and a lounging place for students are also allotted. A doorway to the campus opens out on the north. On the south a large area space intervenes between the foundation wall and the quadrangle. It will be roofed with a grating and bull's-eye glasses and is provided with a light track and tram-car. This opens out directly on Amsterdam avenue, at the door shown in the cut between the two buildings. It connects with branches running south through the basement of the physics building and also south through the corresponding building across the quadrangle to the west. This track encircles the entire campus through the basements and connecting tunnels, and will take freight of all sorts directly from the street to any building on the grounds.

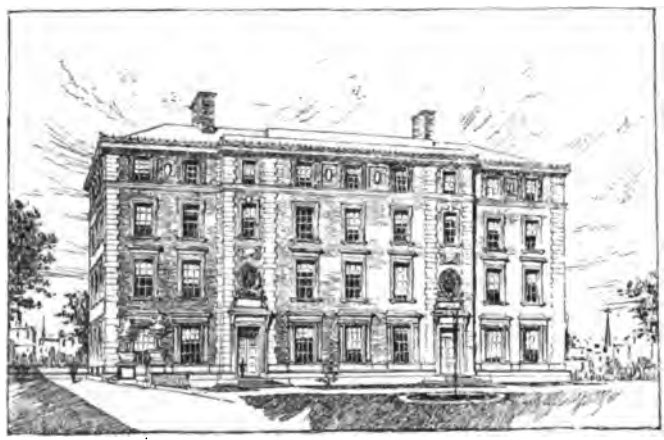
In Schermerhorn Hall an elevator for freight is located in the northeast corner of the main building and extends to the top floor. Stairways are placed in the corresponding northwest corner, and by these alone will entrance and egress be provided for professors and students.

J. F. K.

THE PHYSICS BUILDING.

In preparation for the removal of the University to its new site the first building to be erected for the ultimate exclusive use of one department will, undoubtedly, be that which will temporarily accommodate mechanics and astronomy on its upper floor and modern languages on its third floor, and which will finally be entirely occupied by the Department of Physics, which will immediately occupy the lower stories.

The Physics Building, as it will be called until some fortunate benefactor gives it a name and a few hundred thousand dollars, will be of the smaller unit size, *i. e.*, 50x150 ft., four stories with basement and sub-basement. It is located on the east side of the northeast court, upon which it opens. It will be remembered that Schemerhorn Hall stands upon the north side of this court, which will ultimately be closed on the south by the chapel. Extending, as it does, 150 ft. on Amsterdam avenue, about opposite 118th street, in intimate relation to the end of Schemerhorn Hall, it will produce at once a pleasing and imposing effect.



THE PHYSICS BUILDING.

Two doorways about 40 feet from each end of the building open from the court into halls connected by a north and south passage, and from which ascend and descend the stairways in broken flights. This arrangement, it is believed, will permit the easy handling of large classes with a minimum of waste space.

The sub-basement is about on a level with Amsterdam avenue, and has clear windows on the east or avenue side; on the west or court side, light is obtained from an area outside the foundation wall. The central part of this floor will be mainly occupied by the heating and ventilating apparatus.

There will, however, be four rooms about 20x35 feet, available for such work as calorimetry, vapordensity, gasometry and air pump work, where light is not at all important and fairly constant temperature is desirable. Through this sub-basement runs the "intramural" tunnel and railway connecting with the vault between it and the sub-basement of

Schermerhorn Hall and the University building. All freight will reach the building by this means.

In the central section of the basement will be located the student's coat-room lavatory and a lounging room, also a photometer room and store room. In each end of this floor is a room 50 x 35 feet to be devoted to advanced undergraduate electricity and to general advanced undergraduate work.

The first or main floor is practically given over to lecture purposes. The north section, 35 x 50 feet, is devoted to the large lecture room, seating about two hundred. The south section is occupied by the private rooms of the professor in charge. In the centre is a room 35 x 50 feet for lecture apparatus and museum collections, connecting under the stairs with the lecture room on the north and with the professor's study on the south. On this floor are also a smaller lecture room, seating about seventy to eighty, and a smaller colloquium room, or library. The second floor furnishes, on the north, a room 35 x 50 for general elementary work; on the south, two 35 x 25 for advanced optics and acoustics; in the center, one for photography, 35 x 17, and two research rooms of the same side; two offices, about 14 x 20, and a small lavatory. The third and fourth floors are temporarily cut up into lecture rooms and professors' studies, which will ultimately become available for special work and for the research rooms of candidates for higher degrees and investigators in general. The third floor is divided into five lecture rooms of varying sizes, and eight smaller rooms to be used now as apparatus rooms and private studies, and later as research rooms. Similarly the fourth floor provides five lecture rooms and six small rooms.

Upon the roof is a platform in case it may at any time be necessary to make observations there.

Extending some 18 ft. below the floor of the sub-basement is a "constant temperature room" which may be entered from the *top*, and which will be provided with a double-plate glass trap-door, so that by special illumination and telescopes readings can be made without entering or even opening the room.

An elevator shaft runs from the sub-basement to the attic. The shaft is so large that on two sides a foot to eighteen inches space is left. This will permit the erection of barometers, gauges, etc., which can be easily and effectively managed from the car of the electric elevator, stopping at any desired point. On one wall will run electricity, gas and water, with outlets every ten feet the whole way to the attic; a similar sink pipe will be provided to carry off the water. The floor of the elevator car will be skeleton, thus permitting suspensions through the floor of the car.

Should a very large audience be expected upon some special occasion, it would be a simple matter to transport the necessary apparatus to the lecture-room of Schermerhorn Hall, or even to the theater in the University building.

Some of the leading features of the building are: Absence of piers (the building is the best pier); the absence of slab brackets (one never knows in advance just where one will want them, and they can be put up anywhere very easily with expansion bolts and similar devices); the conversion of the elevator shaft into a vertical research room; the peculiar construction of the constant temperature room, and the convenient disposition of the apparatus collections convenient to all the lecture rooms.

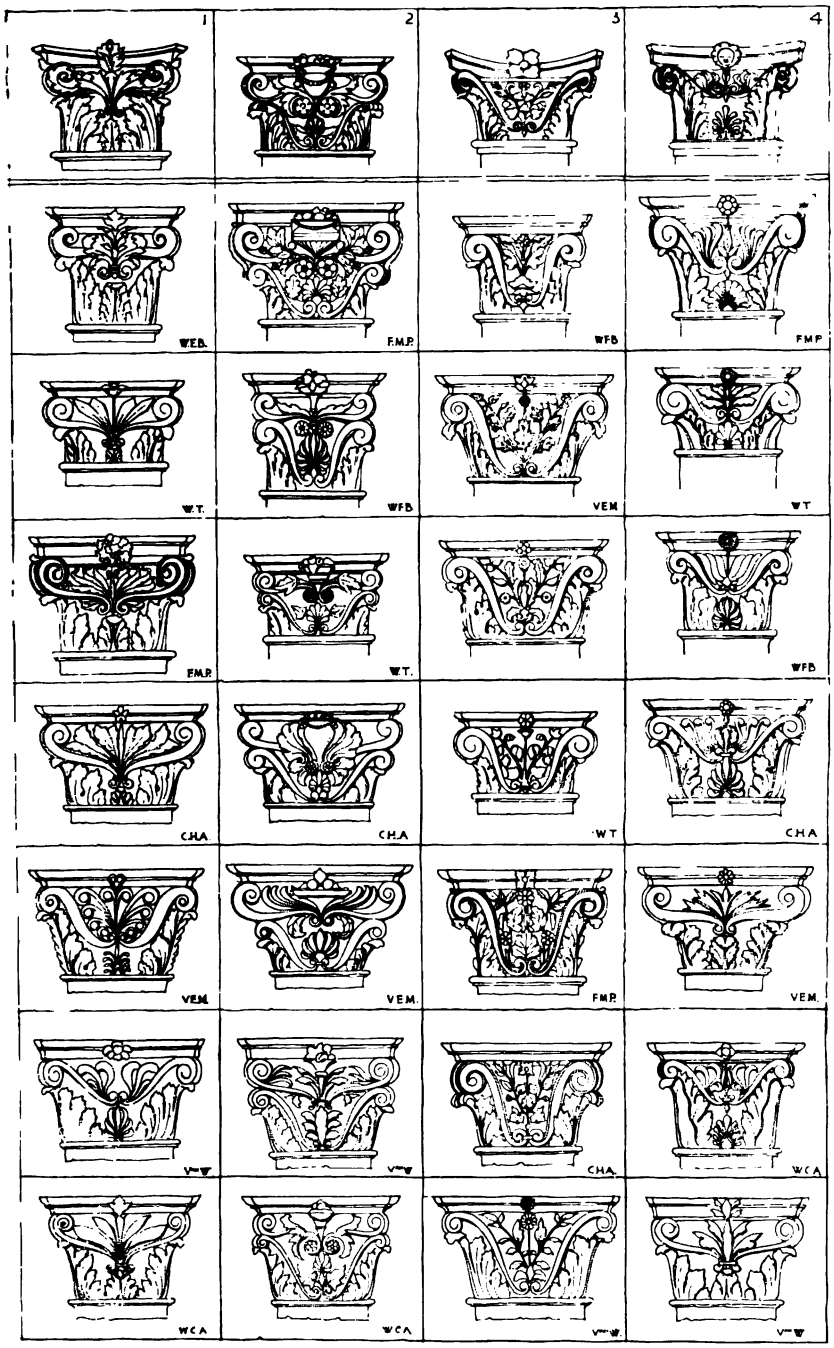
It is confidently believed that, as a result of the most hearty and intelligent devotion of the architects to the interests of those to be housed in the building, a distribution of space and facilities has been arrived at which will give to Columbia one of the most commodious and convenient physical laboratories in the country. WM. HALLOCK.

THE UNIVERSITY DINNER.

The Alumni of the Associated Schools of Columbia assembled on December 16th, 1895, at the first University dinner. It was held at Sherry's, 5th avenue and 37th street, and brought together a good representation from the School of Mines. The plan for combining annual dinners of the several alumni associations is the outcome of the establishment, a year ago, of the University Alumni Council of Columbia College, one object of which is to bring about closer relations between the graduates of the different schools.

Dean Van Amringe, of the School of Arts, presided at the table of honor, and with him were President Low, Mr. Wm. G. Lathrop, Jr., President of the Alumni Association of the School of Arts; Mr. Austin G. Fox, of Harvard; Mr. Thomas Thacher, of Yale; Mr. Hugh L. Cole, of Princeton; Rev. Dr. Van De Water, Chaplain of the College; Mr. Wm. B. Parsons, President of the Alumni Association of the School of Mines; Prof. Henry S. Munroe, Acting Dean of the School of Mines, and Mr. S. R. Avery, founder of the Avery Architectural Library. At the small tables, which filled the room, were grouped about two hundred and twenty graduates of the University Schools, and thanks to the arrangements of the Dinner Committee, of which Mr. Howard Van Sinderen was Secretary, and which is to be congratulated in doing so much toward the success of the event, there was plenty of sociability in a reunion of classmates and members of college societies. It is worthy of remarks that a large number of the older graduates were present.

When the cigars were lighted, Chairman Van Amringe opened the speech-making by touching briefly upon the development of the College, and then introduced the speakers of the evening. First among these was President Low, who referred to the unification of the schools now forming the University, and spoke impressively of the serious questions involved in the approaching removal to the new site. The President drew attention to the fact that though in the past three years Columbia has received as gifts four millions of dollars, she needs a million and a half more immediately, and closed with an earnest appeal to the Alumni for aid. Mr. Lathrop, the next speaker, gave an interesting historical sketch of the development of the College, beginning with the time when the net rentals of its real estate amounted to but £250 per year. He showed that in 1830 this income was no more than $10,000, and that in 1854 the College was $70,000 in debt. Until 1867 the "upper estate" was only an expense. Other addresses were made by Dr. McBurney, of the College of Physicians and Surgeons, Mr. Wm. B. Parsons, Rev. Dr. Van De Water, Mr. Austin G. Fox, Mr. Thomas Thacher and Mr. Hugh L. Cole. R. P.



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OUTLINE SCHEME FOR MINE SURVEYING.*

BY EDWARD B. DURHAM E. M.

Location of Stations. The first step in any survey is to locate the stations, a more difficult operation underground than on the surface, because of the usual irregularity of the openings. Whenever possible this work should be done before beginning the survey. It is of special advantage to do so in an unfamiliar mine, not only for obtaining a general idea of the workings, but by carefully choosing the stations fewer will be needed and the transit work will be facilitated. A chief and three assistants are required; one assistant at starting point, the chief at second station, and other assistants at stations 3 and 4. Each man as he moves about in the level or shaft to select his station, keeps in view the lights of the men at adjacent stations, being careful at the same time to hold his own light in a place convenient for the setting up of the transit, and at the height of the telescope. Care should also be taken to locate stations so as to avoid very short sights. Stations 3 and 4 having been thus approximately located, the chief marks the final position of station 2 in the roof with a spot of paint. The assistant at station 1 now comes forward to station 2, and the chief proceeds to locate station 3, the assistant at that point (3) going

* For further details, and additional methods, see articles on "Mine Surveying" by the writer in Colliery Engineer, March to October, 1895.

forward to station 5. Stations 4 and 5 being approximately located, station 3 can be marked as before. In some cases additional sights will be required from certain stations for the survey of stopes, winzes, etc. Due regard must be paid to such sights or branch surveys in locating the main survey. The stations are marked by spuds, or horse-shoe nails with perforated heads, these spuds being driven into a timber over the station, or better into a wooden plug in a hole drilled for the purpose in the roof. The latter is preferable because timbers are liable to be displaced. To aid in finding the stations it is well to paint the number on the wall, or score the timber with an axe.

Methods of Surveying.

To ascertain merely the distance and direction from one point to another, a traverse is run, with but few side notes. If there are to be several projections of the workings, however, or if cross sections are to be made, much fuller notes will be needed. Accuracy and quickness are of the first importance and there is frequent opportunity underground for the exercise of ingenuity in conducting the work.

I. RUNNING UNDERGROUND TRAVERSE.

A traverse is a survey line run by distance and direction, usually broken into courses. For mine work the courses are measured with a tape, and the angle between two adjacent courses by compass or transit. The taping may be done horizontally, or on a slope whose vertical angle is read by the transit, and the measurement reduced to the horizontal.

The compass is often used for rough traverse work, or for side lines, or as a check against gross errors in the transit readings. When so used the difference between the B. S. and F. S. at each station must be calculated. The angle thus found is used for plotting, and not the bearings as read, because of the danger of local attraction.

For accurate transit work, determine the angles by four to six repetitions. Where great exactness is necessary, these sets of readings may be repeated a number of times, and by comparing the results, any serious difference is discovered.

Method by repetition. Set the plates at zero, and point telescope at back station, clamp by lower clamp, loosen plates, point on

forward station, clamp, read and record the angle. This is the first reading. Next loosen lower clamp, without resetting plates, and set again on the back station, loosen plates, point to forward station and clamp plates. This angle is not read, but it forms the second observation. The remaining observations of the set are made in the same manner as the second, except that the second half of the set is made with the telescope reversed instead of normal. This prevents cumulative errors due to imperfect adjustment. After the fourth or sixth observation the angle shown on the plates is read and recorded. To this angle add the number of full circles of 360° each that have been passed through, and divide by the number of observations. In order to check the vertical angles and eliminate all the errors possible in connection with accurate repetition work, the angles should be read with telescope both normal and reversed. With the three tripod method, or where the sights are taken parallel to the stations, observations should be made on the back-sight as well as on the fore-sight. This gives four readings which can be averaged together for the final angle. This method should be used only where the survey can be closed, or where accurate work is not required.

Determination by Azimuth is by reading the angle from the north end of the meridian, to the right, around to the course. This angle is known as the azimuth, or meridional angle of the course. The azimuth of the meridian looking north is taken as zero. In commencing a survey by this method the plates are set at zero, and the instrument placed so that the telescope in its normal position will point along the meridian. It is then fastened by lower clamp, the plates are loosened, and the telescope swung around on the first course, the reading on the plate being the azimuth of this course. With plates clamped, the instrument is moved. to the next station at the further end of first course. There with plates still clamped, the instrument is set with the telescope reversed, and pointed backward along the first course, securing by lower clamps. Then the plates are released, the telescope brought to the normal and pointed on the second course. The reading will be the azimuth of this course. This operation is repeated at each station. It is a little quicker than the method by repetition but does not give the same accuracy. Errors of adjustment may be modified by taking the alternate readings with telescope normal on B. S. and reversed on F.

S. When possible the tapings are made horizontally, otherwise they are inclined and the angle of inclination measured, so they can be reduced to the horizontal. It is best not to attempt to carry forward the vertical heights by the transit survey, but to determine the elevations by a line of levels run through the workings (unless all the stations can be in the roof, so that the angle of inclination, and the taping, can be measured parallel to them). The field notes will consist of the station number, the reading of the angle, the magnetic bearings, both backward and forward as checks on the angle reading, also the distance and the angle at which it was measured. Later a line of levels is used to determine the elevations. This system is best adapted to flat veins, where long sights with the level can be easily taken in any direction, and especially for coal mines where the gangways are flat with a low roof, and where accurate levels are necessary for haulage and drainage. The sights into the rooms may be inclined, but can be easily reduced to horizontal, and do not cause any annoyance.

For mine work there are *two general classes of signals*, viz.: *lamps* mounted *on tripods*, and *plummets*.

The *method of using plummets* hung from stations fixed in the roof, or in the timbers of the mine, is the same as the ordinary method of surface surveying where plumb-bobs are hung from tripods over the stations, or a point is held on the station itself. The plummets may be ordinary plumb-bobs, and the sight taken on the string, with a light placed behind it, or plummet lamps may be used, in which case the sight is taken on the wick tube. Plummets could also be used in mass deposits where the work is carried on in floors and the traveling ways are low and timbered. The survey of each floor is made separately as if each were a flat deposit, and then all the separate surveys connected through the shaft.

The *three-tripod-method* is suited to a greater variety of work than the previous one, and by it all the measurements required for a complete location of any point are made in one operation, without regard to the inclination of the deposit. Three tripods are used, one for the forward signal, one for the back, and one for the transit. The point of sight on the lamps, and the center of the horizontal axis of the transit, are at exactly the same height above the tripod head. These tops are interchangeable. Before it is moved

from its position each tripod carries, first the F. S. lamp, then the transit, and finally the B. S. lamp. Therefore at each station it is only necessary to move the back tripod to the extreme front, changing the lamps and transit so as to place the instrument on the center tripod.

Read the magnetic bearings both forward and backward as checks, taping the distance from the horizontal axis to the point of sight of the forward signal. The vertical angle is read to the point of sight, either once or a number of times according to the accuracy required, and finally the distance of the horizontal axis above or below the station point is measured. Record all these readings.

In this method the whole line of the survey is run on the line of sight through the horizontal axis of transit, and points of sight of lamps. Hence the vertical heights, as given by the survey, are for the horizontal axis of the instrument, and the elevation of the station is found by calculation.

Leveling. When the workings are nearly horizontal, and lines of sight in descending will not strike the roof too quickly for accurate work, the elevations are determined by the wye-level used in the ordinary manner. The rod for underground leveling must be short. A simple method for taking the readings is to place the point of a horseshoe nail against the side of the rod, and hold a light or a sheet of white paper behind it. The nail then stands out as a black line, and is easily bisected, while the flames illumines the cross hairs.

Details. Aside from the main traverse it is necessary to determine the shape of the workings for plotting on the map. The details are conveniently obtained by radiating sights, or by tape alone. The first sight is taken from the station at which the transit is set, by reading the angle from the back course around to the point whose location is to be determined, and measuring the distance from the transit to the point, together with the inclination of the taping. If the points chosen are at prominent angles in the wall, they are plotted on the map and joined by straight lines, the accuracy of the resulting outline of the workings depending upon the care taken in choosing the points. This method would be the best for a large stope where a single station could be set and the whole outline taken in at once.

The most convenient method of recording detail work is to

make a sketch of the workings on the right hand page of note book, opposite the traverse notes, with the stations noted on it. Mark the stations on sketch, and record the observations about its periphery, putting down angle, distance and inclination of taping, if not horizontal. The sketch thus shows the approximate relation between the different observations and to the station itself. The notes taken should be full and free from ambiguity. No attempt should be made to save space in the note-book at expense of clearness.

In narrow workings, as in tunnels and drifts, the details can be quickly determined by right angle offsets from the tape laid on the ground between stations, noting the distances on the main tape and also the offsets to the right or left. In other places tape surveys can be made by laying out triangles from known lines as a base, either to determine the location of the point at the apex, or to use the sides as lines from which to take offsets. Often a tape survey can be used between two radiating sights to get the outline between them which may not be visible from the instrument. Sometimes a compass survey can be run from a main survey to determine the details of some corner, using either radiating sights, or running a small traverse, and taking offsets from its courses.

With flat deposits the principal map will be the horizontal plan with levels noted on it so as to show the lay of the floor of the mine; sometimes contours of the floor are drawn, and perhaps a profile of the haulage lines. When the deposit is inclined from about 10° to 30°, a projection on a plane parallel to the general plane of the vein is necessary in addition to the plan, in order to show the extent of the workings on each level. On the horizontal plan they may be much confused, by overlapping one another. In collecting data for vertical projections, a profile of the floor is made by leveling, measuring at intervals the vertical distance from the floor to the roof. Cross-sections showing the dip, the general arrangement of workings, and thickness of the deposit are constructed by the same method. Sometimes a large stope can best be measured, especially to determine the volume extracted, by radiating sights to all points of its interior.

II. SHAFT SURVEYS.

If there be but one vertical shaft, the alignment must be transferred from the surface down this shaft. First, a line having a

known direction is run across the top of the shaft, and from two points upon it plumb-bobs are suspended by fine wires. In the underground workings the line through these wires is prolonged and permanently marked, thus becoming the base from which the underground courses are calculated. The measured depth gives the elevation of the bottom of the shaft. The exact relation of one of the wires to the centre of coördinates is determined, by which all the points underground are referred to the same origin as the points on surface.

In suspending the wires it is convenient to lower them over the edge of a plank at the top of the shaft. A transit is set with its telescope pointing on the desired line, the further wire set exactly on that line, then the near wire is brought into position. If the transit is far enough from the shaft both wires can be viewed without changing the focus. Their distance apart should be as great as possible, but care must be taken that the wires shall nowhere touch the sides of the shaft. They should also be sheltered from draughts liable to cause oscillation. The lower ends carrying heavy bobs should be placed in pails of water, on which a little oil is placed to quiet vibration due to falling dirt or water in the shaft. As a further protection, the pails may be covered with boards perforated with a hole, three inches in diameter, through which the wire passes. For prolonging the line at the bottom, a transit is set up exactly in line with the wires. The transit should be far enough away so that both wires can be seen without changing the focus, and the line is transferred to two plugs firmly set in the roof.

If there be two shafts, one bob is hung down each, and the course of the line between the wires is determined on surface. Then a traverse from one to the other is run underground, starting with an assumed meridian, and the course from one wire to the other is computed. The difference between the computed direction and the true course of the line between the wires gives the error in the assumed meridian, and this correction, applied to all the courses, refers them to the same meridian as the surface survey.

Shafts with an inclination not greater than 50° can be surveyed by ordinary methods with a plain transit, but, above 50°, it is necessary to use either a top or side telescope to carry the line down the shaft. The top telescope is preferable, because, when properly adjusted, it moves in the same vertical plane as the main telescope, and the horizontal angle can be read with accuracy, but allowance

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the inclined distances measured in the mine. The plan on the plane of the vein will resemble the horizontal plan in outline, but will be larger on the dip as the former has been foreshortened in that direction. The plan on the vein is very useful in showing the area of the worked out portion of the deposit, and distances between any two points on the map will give the distances measured in the mine along the vein, as closely as an irregularly warped surface can be represented on a plane.

NOTES ON THE ANALYTICAL DETERMINATION OF SILICA.

By FERDINAND G. WIECHMANN.

The quantitative determination of silica in its various modifications has long been a matter of importance to chemists and geologists. The problem is one of especial interest where some of the various forms of silica occur together and where the separate determination of these forms is required.

In this connection, the following memoranda from the writer's laboratory experience may prove acceptable as a slight contribution to the literature on the subject. To Mr. C. E. Brainerd credit and thanks are due for the painstaking execution of the analytical work here recorded.

A. Determination of Crystalline Silica.

The material used consisted of crystals of white quartz. The analytical determination was made in the following manner: One-half gramme of the finely powdered sample was intimately mixed with ten grammes of the mixed carbonates of potassium and sodium (1: 1). This mixture was then fused over a blast-lamp, dissolved in water and hydrochloric acid, and this solution placed into a platinum dish and evaporated to dryness.

After this had been done, the dish with its contents was kept for sixty-four hours at a temperature of 101° C. It was then kept for fifteen minutes more over the direct flame of a Bunsen burner, the platinum dish being heated to a dull red.

The contents of the dish were then taken up with water and

dilute hydrochloric acid, and the silica filtered out, well washed, dried, ignited and weighed.

The filtrate and wash-water resulting from above treatment were evaporated to dryness, then dehydrated for 16 hours at 101° C., and thereafter kept for 15 minutes over the direct flame of a Bunsen burner and further treated as specified above.

The resulting filtrate and wash-water were once more subjected to the same treatment. The results obtained were as follows:

1st evaporation yielded	99.20%	SiO_2
2nd " "	0.64	"
3rd " "	0.00	"
Total SiO_2	99.84.	

This emphasizes the importance of drying precipitates of this description at temperatures sufficiently high. As Ostwald, in his *Scientific Foundations of Analytical Chemistry*, remarks in discussing the washing of precipitates: "The drying temperatures must therefore be raised far beyond the boiling-point of the liquid in order to practically get rid of the last traces of the latter, and the finer the powder the higher must the temperature be. Colloidal substances require the highest temperatures."

B. Action of Potassium Hydrate, Sodium Hydrate and Sodium Carbonate on Crystalline Silica.

In studying the influence of these reagents on crystalline silica, the same material referred to under *A.* was used. In this connection it was desired to obtain information on two points.

1st. To what extent will crystalline silica be acted on by various strengths of the reagents named.

2nd. How will the action of these reagents on crystalline silica compare: *a*, on boiling over direct flame; *b*, on digesting on a boiling water bath.

For these trials the quartz crystals used were finely powdered, the powder passed through very fine silk bolting cloth, washed on to a No. 590 S & S., filter paper with pure water and the washing continued until the wash-water came through perfectly clear. The powder remaining on the filter was dried for 5 hours at 101°C and then for an additional 5 hours at 120°C.

Table I., following, embodies the results obtained in testing the

behavior of this crystalline silica with 10% and 25% solutions of the reagents employed.

In each instance 1.0 gramme of the silica was boiled over direct flame for one hour, with 100 C.C. of the reagent named. The solution was then filtered, thoroughly washed with boiling distilled water, then dried, ignited and weighed. Loss in weight determined, is recorded in column 3 of the table.

The residue from this operation was then once more subjected to identical treatment. Loss in weight resulting, is recorded in column 5 of the table:

TABLE I.

(1.0 gramme of material used in each experiment. Total SiO_2= 99.84%).

Reagent Employed.	Residue After First Hour's Boiling.	Actual Loss in Weight of Silica.	Residue After Second Hour's Boiling.	Actual Loss in Weight of Silica.
10% KOH.	0.9907	0.77	0.9863	1.21
25 "	0.9886	0.98	0.9833	1.51
10% NaOH	0.9861	1.23	Lost	
25 "	0.9792	1.92	0.9700	2 84
10% Na_2CO_3	0.9963	0.21	0.9948	0.36
25 "	0.9974	0.10	0.9913	0.71

From this table it appears that of the three reagents employed and under the conditions specified, sodium carbonate exercises the *least*, sodium hydrate the *greatest* solvent action on crystalline silica. The potassium hydrate is intermediate between the two.

Table II. shows the extent to which the crystalline silica was attacked: *a*, by being boiled over direct flame for two hours; *b*, by being digested on a boiling water bath for two hours. During digestion the temperature of the solution itself was 80°–82° C.

TABLE II.

(1.0 gramme of material used in each experiment. Total SiO_2 in material=99.84%.)

Reagent Employed.	After Boiling for 2 Hours.		After Digesting for 2 Hours.	
	Residue.	Actual Loss in Weight of Silica.	Residue.	Actual Loss in Weight of Silica.
10 % KOH . . .	0.9863	1.21	0.9943	0.41
25 "	0.9833	1.51	0.9955	0.29
10 % Na_2CO_3 . .	0.9948	0.36	0.9953	0.31
25 " " . .	0.9913	0.71	0.9948	0.36

Table II. shows—as was to have been expected—that, *cæteris paribus*, boiling caused the crystalline silica to be more strongly attacked than when it is digested on a boiling water bath.

C. Action of Potassium Hydrate and Sodium Carbonate on a mixture of Crystalline and Amorphous Silica.

As sodium carbonate had thus been found to attack crystalline silica but slightly, it was decided to compare its action with that of potassium hydrate on amorphous silica. For, if sodium carbonate should dissolve amorphous silica as well as potassium hydrate is known to do, while attacking crystalline silica but slightly, it would prove a valuable medium for effecting separation of these two modifications of silica.

The sample experimented with was a diatomaceous earth from Virginia, which on analysis was found to have the following composition on the dry substance.

Fe_2O_3	3.63%
Al_2O_3	9.74%
CaO.	1.08%
MgO.	2.21%
Total SiO_2	83.07
	99.73

Table III., following, shows the results obtained in the tests made.

TABLE III.

(1.0 gramme of material used in each experiment. Total SiO_2 in sample=83.07%.)

Reagent employed.	Silica brought into solution by digesting on a boiling water-bath for three hours.
10% KOH.	26.04 per cent.
25 "	30.82 " } Duplicates.
	29.56 " }
10% Na_2CO_3	2.85 per cent.
25 "	4.42 "

This of course demonstrates that sodium carbonate cannot be used to secure the separation desired, and furthermore, that a 25% solution of protassium hydrate is—all things considered—best adapted for the purpose.

D: Scheme of Analysis.

The analytical scheme decided upon for the determination of: Total silica; water-soluble silicates; crystalline silica and silicates insoluble in potassium hydrate solution (strength 1:4); amorphous silica (diatomaceous earth), is as follows:

TOTAL SILICA. Mix one-half gramme of sample intimately with ten grammes of the mixed carbonates of potassium and sodium (1:1). Fuse over blast-lamp. Dissolve in dilute hydrochloric acid. Evaporate to dryness and drive off all chlorine. Take up with water and hydrochloric acid. Filter, dry, ignite, weigh. Record as total silica.

WATER-SOLUBLE SILICA, ETC. To one gramme of sample add one hundred cubic centimeters of water. Boil for one-half hour. Filter and wash well with boiling water.

This yields a filtrate and a residue on the filter.

FILTRATE. To filtrate and wash water combined, add hydrochloric acid. Evaporate to dryness and determine the silica as before described. Record as silica from water-soluble silicates.

RESIDUE. Wash into a beaker with the least possible water. Add one hundred cubic centimeters of a 25% solution of potassium hydrate. Boil for one hour. Filter and wash well with hot water until wash water no longer reacts alkaline to phenol-phthalein.

The residue is dried. Ten grammes of the mixed carbonates of potassium and sodium (1:1) are intimately mixed with the residue and this mixture then fused over a blast lamp.

The fused mass is then dissolved in water and hydrochloric acid, and the silica determined as before. The silica thus obtained is recorded as, crystalline silica and silica from silicates insoluble in potassium hydrate solution.

The remainder found on subtracting the sum of the water soluble and the crystalline silica, etc., from the total silica, is recorded as amorphous silica.

Should it be preferred to determine the amorphous silica direct, and not by difference, of course it will only be necessary to evaporate the filtrate and wash water obtained by the treatment with the potassium hydrate solution, and then to ascertain the silica present therein, in the usual manner.

Appended are the results of six analyses made according to the scheme above described:

Description of Sample.	Locality.	Color.	SiO_2 from Water Soluble Silicates.	SiO_2 from Crystalline and Water Insoluble Silicates.	SiO_2 Soluble In 25 Per Cent. KOH Solution.	Total SiO_2.
Diatomaceous Earth.	Virginia.	Black.	.16	48.39	31.16	79.71
Diatomaceous Earth.	"	White.	.13	51.85	36.39	88.37
Diatomaceous Earth.	"	White.	.06	55.97	28.51	84 54
Diatomaceous Earth.	North Carolina.	White.	.14	37.19	36.89	74.22
Diatomaceous Earth.	Virginia.	Yellow.	.10	53.41	29 56	83.07
Siliceous Earth.	Germany.	Slate.	.15	14.56	72.01	86.72

THE INSTRUCTION IN ARCHITECTURAL DRAWING AT COLUMBIA UNIVERSITY.

By PROFESSOR WILLIAM R. WARE.

THE drawing done by an architect lies midway between that of the artist and that of the engineer, being controlled partly by considerations of fact and partly by regard for the appearances of things; partly by geometrical conditions, and partly by the skill and judgment of the draughtsman. In executing them he is accordingly at once an artist and a mathematician. He handles his instruments of precision, his T-square, triangle and dividers, with as free a touch as the painter his pencils and brushes, and on the other hand subjects his free-hand work to a constant process of reasoning and measuring, and though without scale or compasses, never lets his Euclid go out of his mind.

Of these two procedures we give precedence in time and in importance to the last. We begin, to be sure, with the use of mathematical instruments, so as to establish at once a certain standard of exactness. But we discontinue their use as soon as possible and find every advantage in doing everything free-hand until most things are done. For the draughtsman who has been trained only with the dividers and ruling-pen, however skilful he may become, is as helpless when they are not at hand as he was before he began to learn their use, while the man who can do whatever needs to be done without them has no difficulty in doing it with them. They come to him then as helps and auxiliaries, which is what they should be, not as necessaries. He is thus saved that early experience of anxiety and caution in their use which produces a hard and timid drawing at the hands of a hard-fisted and merely mechanical draughtsman.

Mechanical drawing being thus eliminated, as a special branch of study and discipline, and left to be taken up when occasion requires, and when it will present no difficulty, what remains falls naturally under half a dozen different heads—Tracing, Copying, Graphical Construction, Graphical Discussion, Pen-work, Brush-work, Out-door Sketching and the Study of the Orders. Under all of these, as in all endeavor, there are to be recognized the two elements, familiar in the Latin Grammar as the object or end, and as the manner, means and instrument by which the end is to be at-

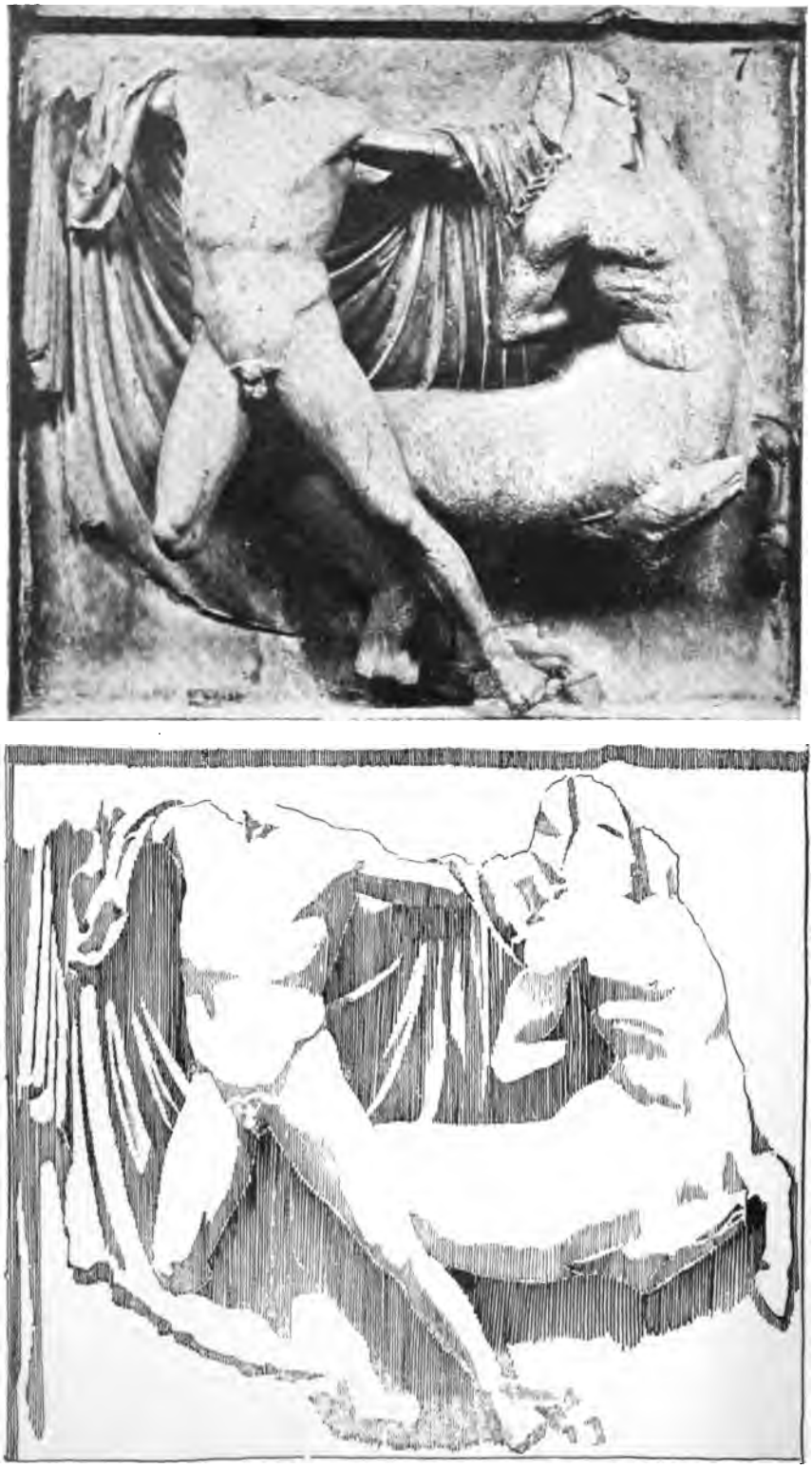


PLATE I. TRACING FROM PHOTOGRAPH. B. W. M.
(Reduced in size about one-third.)

tained. There is a definite conception of the form to be depicted, which is the intellectual and imaginative element—and there is the skill in execution by which the disciplined eye and hand are enabled to realize this conception. The draughtsman has first to get a clear idea of the shapes to be delineated, and then has to compel his hand to the adequate representation of it.

These are in their nature two separate tasks, and for beginners to attempt them both is, in general, and in the case of all but a few specially gifted persons, too much to undertake at once. We accordingly treat them separately. This is effected by beginning the study of draughtsmanship with Tracing.

I. Tracing.

In Tracing, which is drawing upon transparent paper laid over the "copy," the question what to do does not arise, since there is no uncertainty as to the size, shape or position of the lines to be made. Substantial accuracy of form is secured in advance, and it would seem as if a merely mechanical fidelity would suffice to produce a *fac-simile*. But in a work of art, every line, besides shape and position, has a spirit and character of its own, and to seize and reproduce this is enough to occupy the beginner's best attention. Even when, as is generally the case, a line needs to be perfectly even and uniform from end to end, and as it were, to possess no individuality of expression at all, this negative character is one which requires care to secure. The tracing paper thus relieves the student of responsibility for one-half his task, only that he may devote himself the more efficiently to the other half. At the same time the lines beneath his paper secure him from disaster, and this assurance gives him confidence and courage to attack the task which remains, a task which after all comprehends the main substance of the matter. For in the practice of tracing we require that the forms shall be as fully analyzed as if they were to be drawn from memory, and the lines made of as fine a quality as the student can command, and with as much purpose as if the work were a work of original design. Instead of crawling along the line, as a child works with his Transparent Slate, our men are taught to trace with the same animation and spirit as if the original were not immediately under their hand. They soon find that a tracing may be as brilliant and effective as a copy. The only difference is that there is greater facility and boldness in the procedure and more accuracy in the result. (Pl. I.)

This sort of tracing exacts the closest care and attention. It trains the hand, gives acquaintance with form, and teaches just what it is important to do and what it will do to leave undone. Thought and feeling are indeed so far from being replaced by a dull mechanical procedure, that they are, on the contrary, made only the more intelligent and sensitive by being concentrated upon this limited task.

Most of this work is done with the pen, pencil-marks upon tracing-paper being neither distinct nor durable. The outlines of course are traced, from prints or photographs, just as they are found. But the shading, even in the case of wood-cuts, is not textually reproduced, the forms of the shades and shadows being rendered by a series of flat tints. These are sometimes put in with the brush, but more often with the pen, parallel vertical lines being employed just as in drawing. This work is indeed, both in the outline work and in the shading, an admirable introduction to draughtmanship with pen or pencil. The brush is in constant use, however, in making tracings of examples of colored decoration from prints of Egyptian tombs, Greek vases, or tiles and terra cotta of every period. The outlines are then sometimes drawn with the pen and filled in with color, which is often laid on the other side of the paper. But these may be dispensed with and the tracing made with the brush altogether. This is particularly effective in tracing anthemions and honeysuckle work from Greek vases, and in this work Japanese brushes prove specially serviceable.

These exercises are immediately utilized in the service of the historical studies which compose a chief part of our course. While practicing the essential principles of draughtsmanship in making tracings from drawings, engravings and photographs, our students are at the same time accumulating valuable memoranda for future reference. The tracing books in which this work is stored away become, before the end of the course is reached, a priceless possession. (Plate II.)

To this end we have accumulated a considerable mass of material illustrative of Architectural History. Part of this is of the nature of a gigantic scrapbook, and consists of innumerable portfolios full of prints and engravings, picked up at random as chance may offer, and mounted on cardboard for safer handling. But the chief part and the most useful part of this collection consists of the plates of standard architectural works mounted in like manner. Plates

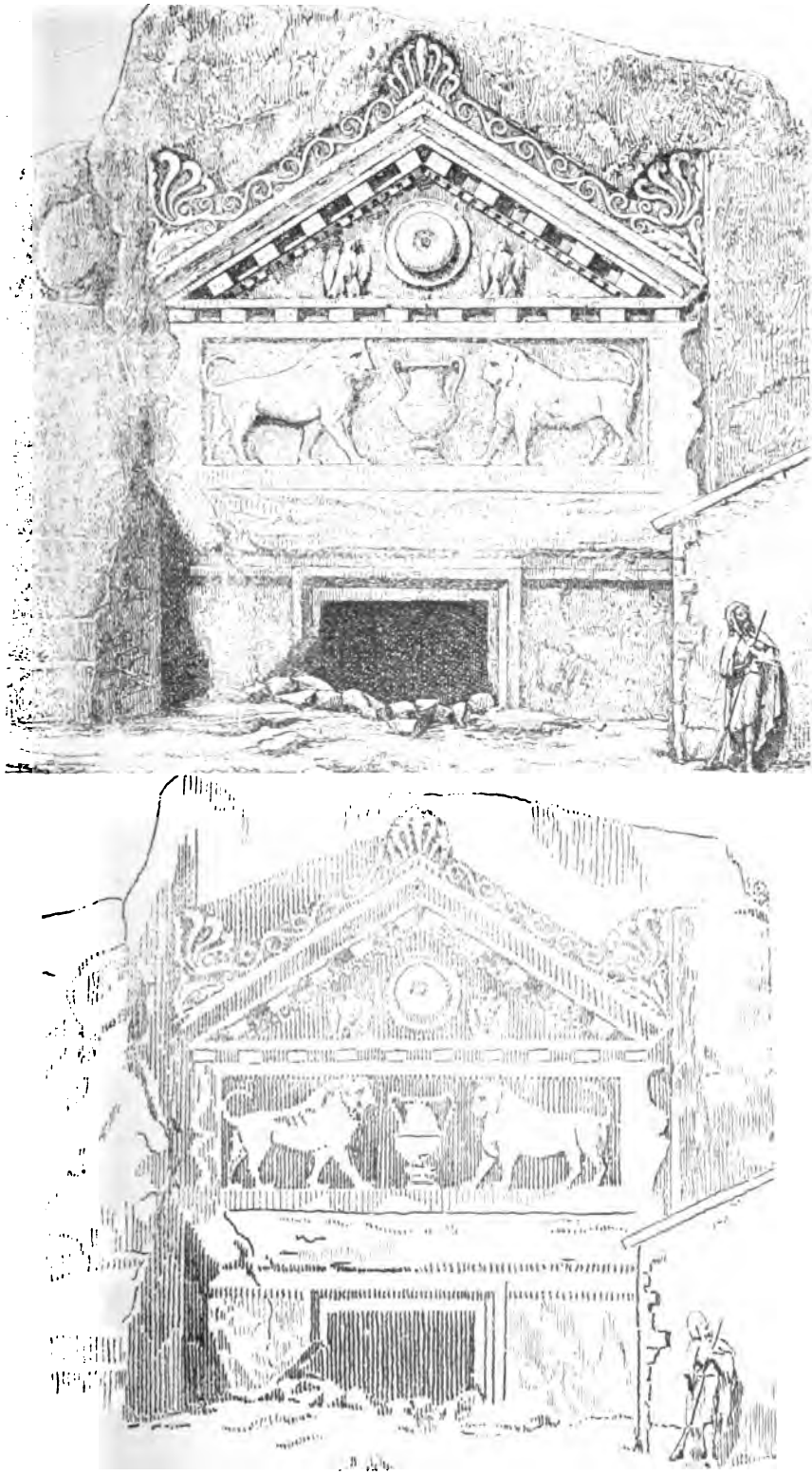


PLATE II. TRACING FROM A WOOD CUT. W. D. A.
In Illustration of the History of Architecture.
(*About the size of the originals.*)

which in a bound volume can be used by only one student at a time are thus made simultaneously accessible to a hundred.

There would seem to be no reason why this procedure should not be equally serviceable in any school. While learning to draw in the most efficient way, classes in Geography, Natural History, and Physics, could easily accumulate an invaluable illustration of the matters in hand.

II. Copying.—Outlines and Shading.

The training of hand and eye, which result from these exercises in Tracing, prepare the student to copy with accuracy and intelligence whatever forms may come before him, whether presented in the flat or in the round, so far at least as concerns the mere execution of the lines. Tracing makes him acquainted with a variety of forms and the way of presenting them, and enables him to delineate them with a firm and workmanlike touch, but it affords of course no practice in the determination of shapes and sizes, and of the proportions and relative positions of the objects to be drawn. In copying, however, whether one is drawing from the round or from the flat, this determination of the outline is one's first concern. But it is so difficult a matter that it engrosses all one's attention, and it is well accordingly for the beginner to defer copying until, as thus by the practice of tracing, some manual dexterity and some critical appreciation of form have been acquired.

The accuracy of observation and quick sympathy of hand and eye needed accurately to reproduce the contours set before them, come to some persons as a natural endowment, while others can acquire them only by long and laborious practice. To such persons the exercises in Graphical Construction, described in some later paragraphs of this paper, are of special service. Like the preliminary surveys of an engineer, they serve to fix certain landmarks and enable him to block out his work. But it is not necessary, in copying drawings, photographs and prints at least, to put off the achievement of work really worth achieving upon subjects really worth working upon, until this skill in drawing outlines has been attained. For the student who is skilled in tracing is in a position to avail himself at once of the devices of transferring and squaring, and of the pentagraph and camera lucida, mechanical aids to which artists habitually resort to secure accuracy of form, but which, though they are by no means wholly mechanical, it is somewhat the custom of the schools to neglect, or even to disparage.

In Transferring, the outline is first traced, then gone over with a soft pencil or charcoal on the other side of the tracing-paper, and then transferred to the paper on which the drawing is to be made by going over it a third time. It then, of course, has to be drawn a fourth time, more carefully still. This repetition affords in itself a valuable discipline.

In Squaring, a rectangular network of lines—threads, wires or pencil marks on tracing-paper—is laid over the original, a similar network is drawn on one's paper, and then the outline is copied one square at a time. A task which is a hundred times too difficult to undertake may thus, if divided into a hundred separate undertakings, be brought within the reach of powers still undeveloped. Each square presents simple lessons of its own which are just as instructive as if it were not part of a whole, and they may be made more instructive still if the second network is laid out to a larger or smaller scale than the first, so that the drawing is reduced, or, still better, enlarged, in size. (Plate III.)

It is one of the advantages of drawing from the flat that it makes the beginner, while slowly acquiring the judgment and skill which shall enable him at last to dispense with these helpful devices, to push on immediately to other equally important matters, such as the study of light and shade, modelling, values, and the relations of things. It thus opens to him the whole world of representative art as a field of endeavor instead of confining him, as drawing from the object must otherwise confine him for a long time, to forms which, if they are simple enough to come within the capacity of his hand, are likely to be too simple to satisfy the desires of his mind, such as cubes, pyramids and cylinders.

The Pentagraph answers the same purpose. It is by no means an automatic machine, and like tracing, requires to produce a good result all the draughtsmanship one has at command. The same is to be said of the Camera Lucida, the manipulations of which are a little more difficult, and which for objects in the round renders the draughtsman a somewhat similar service.

But the outline gives the form of an object in only two dimensions. The third dimension can be shown only by shading, which by representing the play of light and shade within the outline indicates the modelling of the surface. Completely to convey all the delicate gradations of tone which the practiced artist learns to perceive, requires the delicacy of touch which only the long

PLATE III. BRUSH-WORK FROM PHOTOGRAPH AND FROM DRAWING, THE OUTLINES TRANSFERRED BY TRACING AND REDUCED IN SCALE BY SQUARING. R. A. McC., S. G. S.

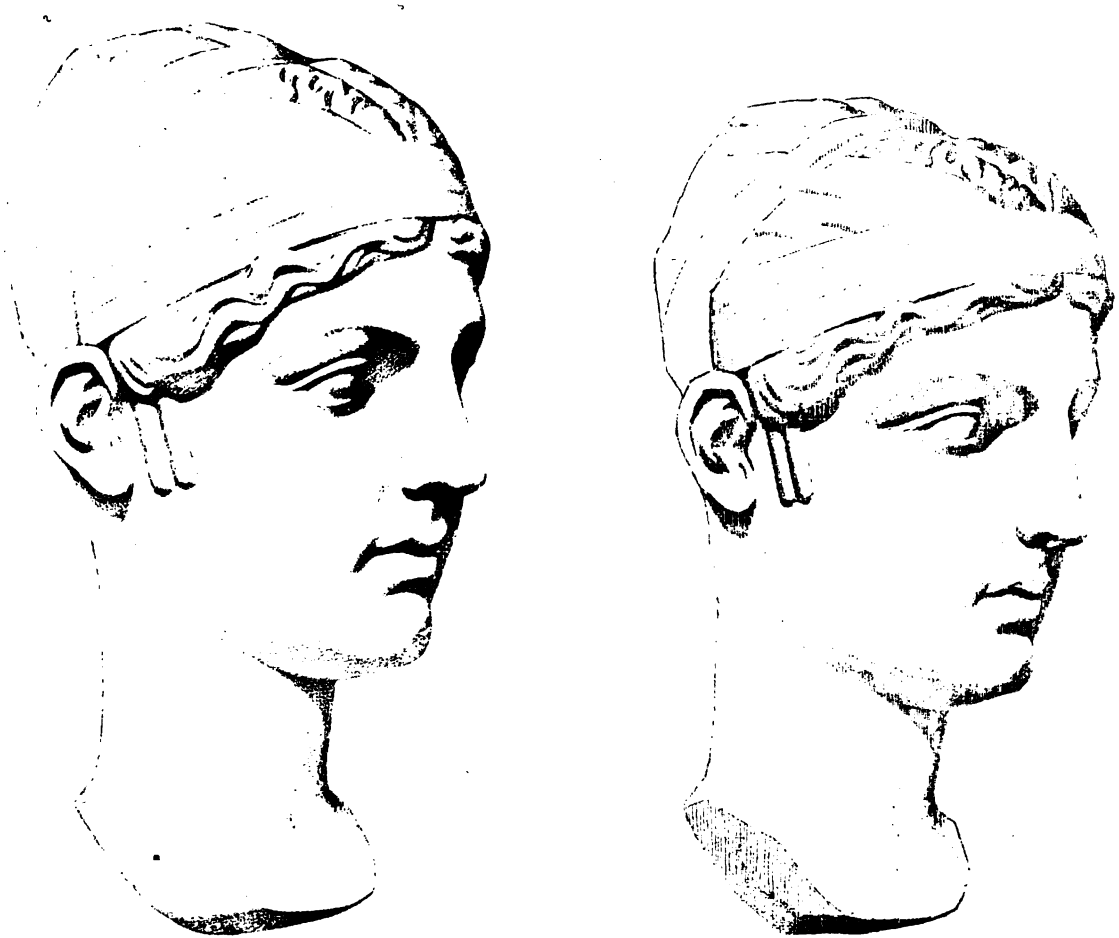


PLATE IV. PENCIL-WORK FROM LITHOGRAPH. HEAD OF FAUSTINA. A. R.

(The lithograph reduced about two-thirds, the drawing one-third.)

practice of the studio can give. This is so much beyond the skill of the beginner that in all schools of drawing the beginner is warned not to attempt it, and is instructed, in treating his lights and shades, to confine his attention to the main masses. He is told to simplify his task by dividing the surface into a certain number of fields, each of which may be regarded as virtually a plane surface, more or less exposed to the light, and may accordingly be represented by a flat tint of the proper grade. This compels a discriminating study of the form to be depicted and at the same time diverts attention from unimportant points of detail.

The subdivisions may be few or many, according to the scale of the drawing and the amount of detail which it is desired to render. Careful discrimination is needed, of course, to get them all of the right shape and size, and of the right tone, or, as the artists say, of the proper *value*. The more numerous the planes, the more delicate the analysis and the more subtle the differences. Objects in the sunlight, if drawn upon a small scale, may be effectively represented, as we have seen by rendering the whole of the dark or shaded side by a single uniform tint. But whether the subdivisions are few or many, each is shown as a plane. They give, of course, only an approximation to the real form, but the approach may be made as close as one chooses by increasing their number. (Plate IV.)

But just as, when we take up free-hand work in preference to mechanical drawing, we nevertheless begin with a little work with the T-square and compasses, so as to establish a certain standard of accuracy, so here we find it best to let the students begin by trying their hand at the representation of rounded surfaces by graded tints. The real fact in regard to the gradations of shadow is thus brought to their notice, and their observation quickened, while their inevitable failure to reproduce the facts, and the unworkmanlike appearance of their work, convinces them, as nothing else would, that a more conventional method of treatment is more within the range of their powers and promises a more satisfactory result.

The skill and dexterity of hand required faithfully to represent these planes is only the skill to produce with the pen or pencil a flat tint of any depth, and this is of comparatively easy attainment. A few hours' practice in making straight parallel lines close together suffices to meet all the demands which a beginner's knowledge makes upon his skill. Stippling, cross-hatching, or the making of

graded tints with shaded lines, straight or curved, such as are to be observed in the lithographs furnished as examples for crayon drawing in schools, had best be deferred to a later period. They divert attention from the appearances to be represented to tricks and devices of representation. (Plate V.)

There is moreover something of the same advantage to be found in the employment of only a single kind of stroke in shading, that there is keeping to a single medium, such as the pencil, or, in music, in studying only one instrument at a time. It limits the possibilities of expression, indeed, but by concentrating effort within a narrow compass gives prompt mastery over all the possibilities within reach. In so doing it not only secures a certain unity of effect, characteristic of the system chosen, but, what is more important, by altogether eliminating the question of the means to be employed, it prevents attention from being wasted in considering which means is likely to be the most effective. The choosing of instruments is, in any art, a task beyond the range of beginners. (Plate VI.)

The treatment in question is so simple that surprisingly good results are reached, almost from the first. It is the special merit of this system that with care and attention even unskilful hands can produce fairly presentable drawings. What is needed by the draughtsman, however, is hands so skilful that they will do good work almost automatically, that is to say will make a line neat and clean, while his attention is mainly devoted to its shape and size. But this masterly touch comes only by much more practice than two or three hours a week afford. This practice our men obtain in the preparation of daily sketches. Each member of the two younger classes hands in every week five pencil sketches, carrying about with him a little pad of smooth paper for the purpose. Sketches of objects or drawings from memory are sometimes prescribed, but for the most part they illustrate current work—projections, shades and shadows, the Orders, etc.—and thus serve a double purpose. They take from five or ten minutes to half an hour to do, time which might otherwise be wasted and incidentally they tend to encourage the useful habit of occupying odd fragments of time to advantage.

These simple manipulations, comprising the making of outlines, straight or curved, with a firm hand, and the making of flat tints of any required depth by parallel vertical shading, the lines of which are without individual significance, have other advantages besides

PLATE V. PENCIL-WORK FROM LITHOGRAPH BY JULLIEN. LION'S HEAD BY JEAN GOUJON, FROM THE HOTEL CARNAVELET. W. T.

(The lithograph reduced in scale about three-quarters, the drawing about one-half.)

PLATE VI. PEN-WORK FROM PHOTOGRAPH. GROTESQUE FROM THE NEW HOTEL DE VILLE. B. VAN B.

(The photograph reduced about two-thirds, the drawing one-half.)

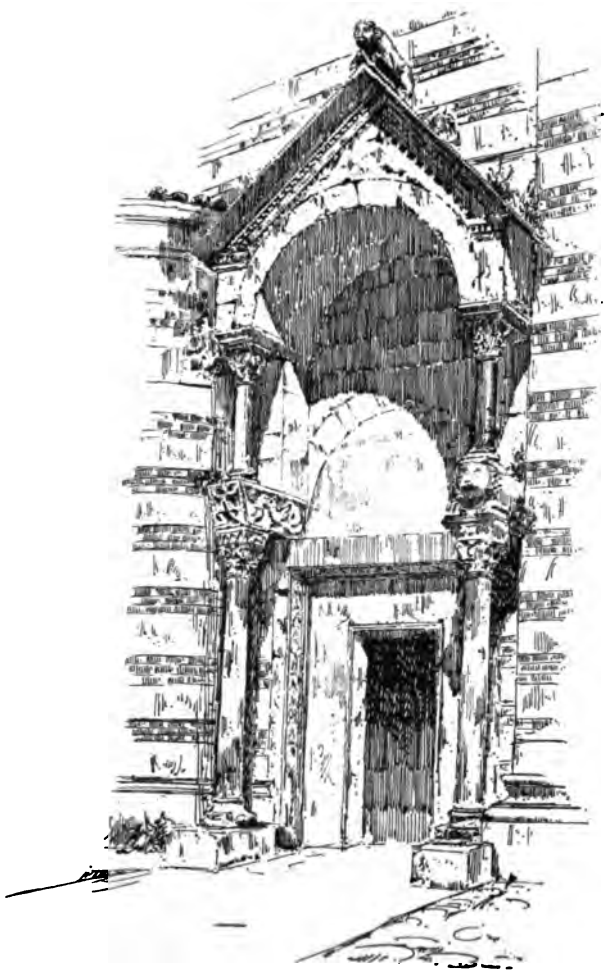


PLATE VII. PEN-WORK FROM PHOTOGRAPH. SIDE PORCH OF THE CATHEDRAL AT VERONA. L. W.

that of being easy to learn. They are easily adjusted to the student's state of advancement and to the degree of completeness desired. They compel a careful study of form, since what is once done is done once for all, without expectation or intention of retouching, and they fix attention upon the main masses of form and of light and shade, the representation of unimportant details being impossible. Moreover the result, however incomplete, is good as far as it goes, and is sure to be clean and bright, not woolly or muddy, as the shaded drawings of beginners are apt to be. It is also eminently suited to the architect's convenience, employing the lead pencil, which is *par excellence* the architect's weapon, and dispensing with the cumbersome and untidy apparatus of charcoal, crayons, stumps and "sauce," a paraphernalia which requires a habitat of its own and is out of place among the books, photographs, and drawings among which an architect lives.

There is at any rate a great saving of time and trouble in making the lead pencil do all it can. It certainly suffices to teach observation, analysis, delicacy of touch, firmness of hand, the importance of minding the masses and the values, knowledge of form and the sources of artistic expression. When the student has learned how to employ this medium it is soon enough to undertake the more difficult manipulations of charcoal and crayon, and at that stage of progress, which our men reach toward the end of their second year, these manipulations are easily learned. But the method under consideration is even better suited to the pen than to the pencil, since it almost precludes blots. In the third year the pen takes the place of the pencil in the rendering of every kind of subject, landscape, buildings, ornament and the human figure. (Plate VII.)

It is moreover eminently a system of interpretation and translation, rather than of the precise imitation of the object copied. In this respect it imparts to drawing from the flat many of the advantages of drawing from the round, the chief merit of which is that it compels the student to convey what he observes in his own language, so to speak, while in drawing from the flat, at least when copying drawings or lithographs, he is tempted to learn the stroke, to imitate the touch, and to produce as far as possible a *fac simile* of the original. But to produce a *fac simile* of a drawing is the last achievement of the most accomplished master, and to set beginners to this task, as is so often done, is mere cruelty. It

condemns them in advance to failure and disappointment. Whatever the merit of their work, it is bound to be discredited by an inevitable lack of likeness. But in the method under consideration a *fac simile* is impossible; the work is mainly the student's own; whatever merit it possesses is manifest, and he gets the credit and the encouragement which his pains deserve. Drawing from the flat, whether from lithographs, prints or photographs, is thus made almost as improving as drawing from the round. For this the elaborate lithographic studies of ornament for crayon drawing afford excellent material. To translate them into so different a language, and at the same time to retain the main points of form and expression, is a liberal education in draughtsmanship. (Plates VIII. and IX.)

So simple and almost mechanical a method of shading would seem, of course, like the ruling in of skies in an engraving, to possess but little flexibility, and is hardly to be expected to lend itself to the expression of nice distinctions. It is interesting and rather surprising, accordingly, to notice what different results it produces in different hands, and how well it can simulate the touch and manner of different artists, fairly well reproducing, for example, the special quality of Calame's well known-studies, drawings which would seem to owe their special character to their own special medium and procedure. (Plate X.)

Much of this work is naturally done upon a small scale, and the drawings made from the cast, and from large lithographs and photographs, often show considerable reduction in size. But it often happens, especially in the drawings made during the weeks given to historical research, that the copies are larger than the originals, details of carving or sculpture being drawn out full-size from photographs or scale drawings, the enlargement being made either by the eye or by the process of squaring. These afford practice in a bolder manner of work. They are executed with charcoal, the brush or the pen. An admirable substitute for the pen is the wooden toothpick, which gives a soft even line hardly to be distinguished from that of the reed-pen. Any soft stick sharpened to a point, such as the wrong end of a penholder, answers of course just as well. (Plate XI.)

These manipulations have also a great advantage in respect of convenience and economy wherever, as is so often the case both at home and at school, a north light, a large room and a sufficient supply of plaster casts are difficult to command. In our own present

PLATE VIII. PEN-WORK FROM LITHOGRAPH BY CICÉRI. HALF-TIMBERED HOUSE. E. J. M.

(Reduced in scale about one-half.)

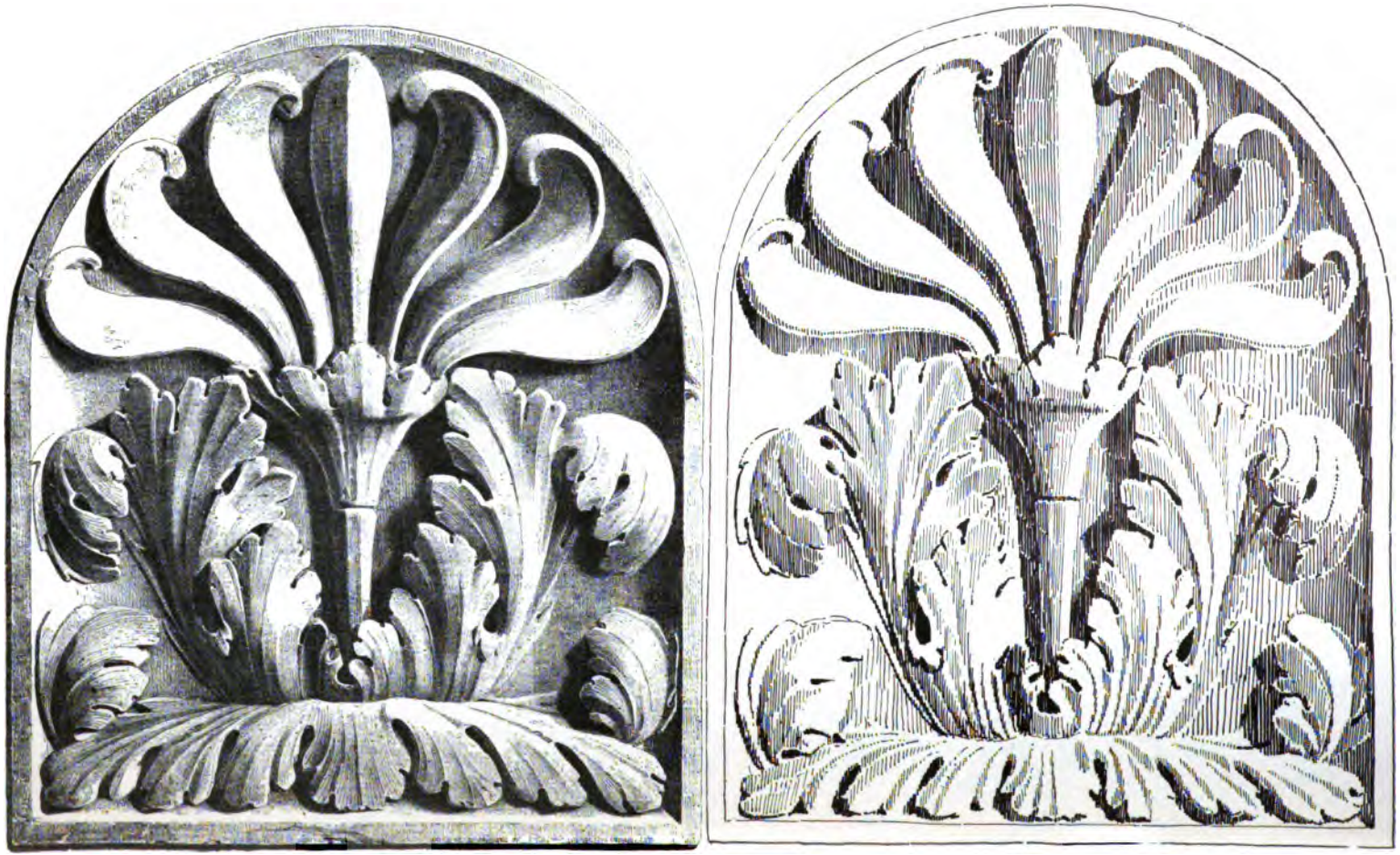


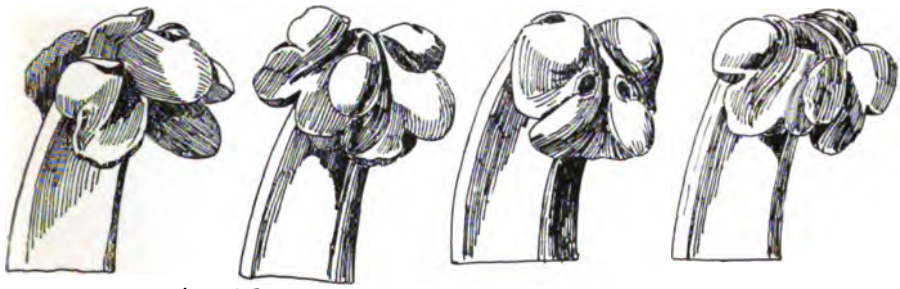
PLATE IX. PANEL FROM LITHOGRAPH BY PLANTAR. TERRA-COTTA ANTEFIX FROM THE VILLA PONIATOWSKI. H. D. B.

(The lithograph reduced about two-thirds, the drawing one-half.)

PLATE X. PEN-WORK FROM A LITHOGRAPH BY CALAME. H. S. H.

(About one-half the dimensions of the originals.)

Voussure de la porte rouge. *Notre Dame de Paris.*



Crochets de Corniche. *Notre Dame de Paris.*

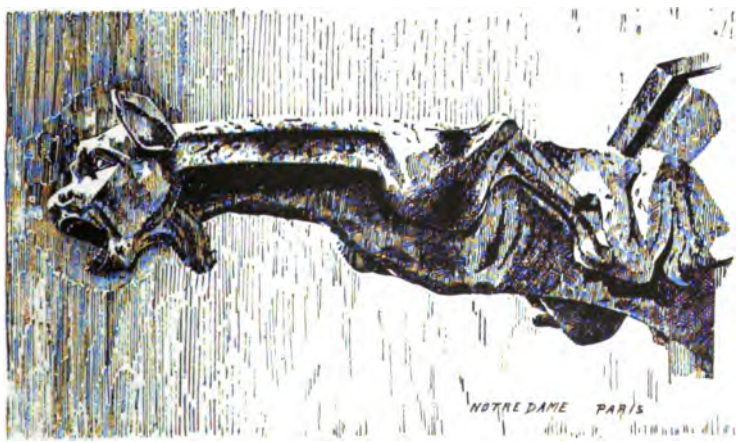
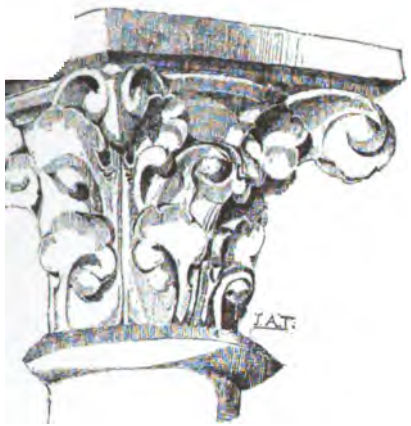
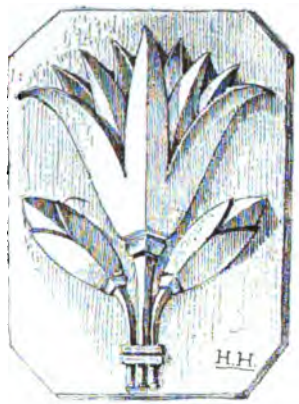


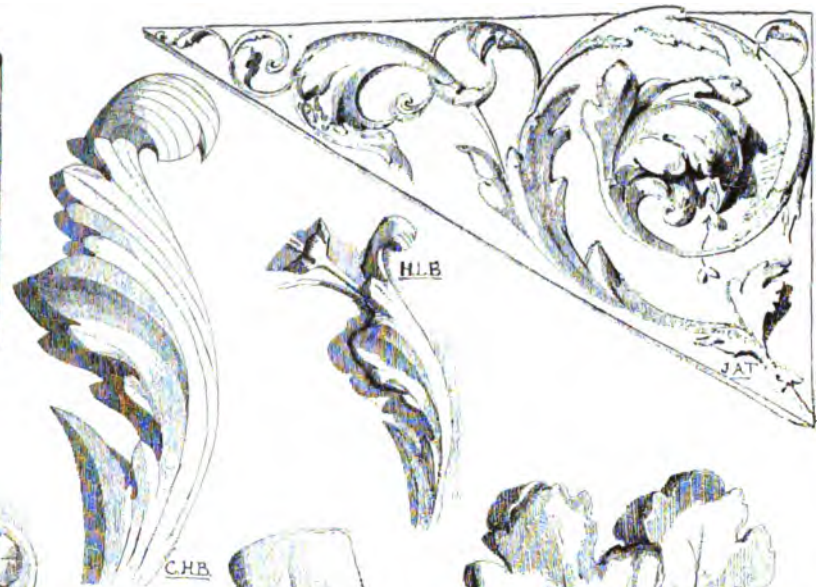
PLATE XI. TOOTH-PICK WORK, ENLARGED FROM ENGRAVINGS AND A PHOTOGRAPH.

J. C. K.

(Reduced about three-quarters, nearly to the size of the originals.)







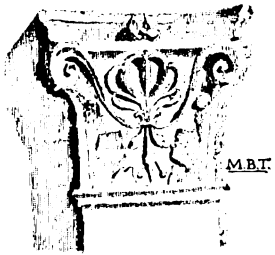


PLATE XII. PEN-WORK AND PENCIL-WORK FROM THE CAST. F. T. H., M. B. T., E. M. A., C. H. B., H. D. B., H. H., J. T. T., J. A. T., S. T.

quarters, where there is no place suitable for drawing from the cast, it has enabled us to get along very comfortably with flat copies. But the trials we have made of it in drawing from the round, using such small casts as can be placed on the draughting-tables, have shown how sufficient it would be for larger work, and how especially rapid and effective it is in the delineation of architectural details. (Plate XII.)

The considerations that make this procedure so convenient for the draughting-room of an architectural school would make it, perhaps, as has already been said of tracing, an acceptable method of learning to draw in other schools, public or private. It is easy to learn, economical of time, and brilliant in its results, so much so indeed, that it seems almost like a trick to enable persons unpracticed in draughtsmenship, as our men are, to turn out good work. But it exercises their intelligence, as well as their powers of observation, and while making a good return for a moderate amount of care and skill, it rewards abundantly the most generous outlay. Moreover, the manipulations are so simple as to make it unnecessary that the subject-matter should be simple too. It thus throws everything open to the beginner, and since, as has been pointed out, it tends to bring the use of flat copies once more into repute, it makes it possible to enlist in the task of learning to draw all the interest a student may have in any subject of any kind.

Practiced in this way drawing appears not only as an accomplishment, that is as a thing desirable in itself, but as means to an end, as a helpful means towards almost any end that either teacher or pupil may have in view. It is because drawing may thus be made useful, not because it is the first step in the practice of the Fine Arts, that it claims a place by the side of writing in schemes of general education.

(*To be concluded in the July number.*)

THE TREATMENT FOR WIND PRESSURE IN MILL CONSTRUCTION.*

By JAMES L. GREENLEAF, C. E.

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The term mill construction is here used to describe those cases of building in which iron or timber columns support the roof trusses and covering. Knee braces connecting the trusses with the columns are usually employed to add to the lateral stiffness of the structure. The lateral wind pressure acts upon the side of the building as well as upon the roof. Each of the two side walls is so thin that its stability as a weight against overturning is of very small account, and hence the condition that the "line of pressure fall within the base of support," although fundamental in the design of masonry walls, is of very secondary significance in this case. Nearly all the lateral pressure is resisted by the shear in the columns and the stresses in the columns due to their lateral resistance to bending.

The small amount of overturning moment which is resisted by the weight on a column acting with a lever arm equal to the half width of its footing is insignificant in nearly all mill construction. In the case of high buildings, however, it becomes too important to ignore.

The resistance of the column to bending under lateral pressure and the stresses due to the oblique connection of the knee braces between the truss and its pair of columns cause the analysis of stresses in a bent of mill construction to be somewhat complicated

* Copyrighted by J. L. G., 1896.

as compared with the case of a simple truss resting upon masonry walls. It is the aim in this discussion to treat all the various cases that can arise in practice, classify them, and deduce a simple yet comprehensive method which will apply to every case. At the least, it will aid in placing upon a sound basis a feature of design which is far too often, although not invariably, decided by "experience" and reference to previous examples.

Attention is called to the independence of the method from the discussion of the hour regarding the mode of action of the wind upon a building. Be that action upon the windward or leeward side of the building, or on both; let its effect be taken as one of pressure, or of suction, or as a combination of the two, the method of treatment to be here presented is unaffected. The amounts, directions, and points of application of the external forces representing the wind pressure may be selected according to whatever assumption seems desirable, but the laws of treatment of them remain unaltered.

Preliminary Discussion.

It is assumed, for the sake of simplicity, that the wind pressure is horizontal and acts only upon the windward side of the roof and building. There is no great complication of the method if the wind pressure upon the roof is taken as an inclined force.

It is assumed that the wind pressure is carried equally by the two columns of a bent, half being transmitted to the leeward column through the medium of the truss.

The weight of the structure is ignored entirely in determining the stresses due to the wind, as it has no influence whatever upon them. It affects the ultimate maximum stresses in the members, and the reactions at the foundations, but the stresses due to wind pressure are independent of the dead weight.

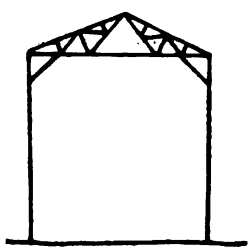


Fig. 1.

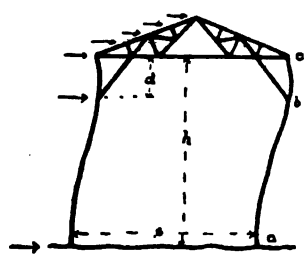


Fig. 2.

Figures 1 and 2, which represent one bent of a building, are selected as typical of mill construction. The bent tends to sway under the action of wind pressure, as shown in Figure 2.

The stresses which are induced may be classified as follows:

1. Stress in the columns, namely: *a*, shears; *b*, longitudinal tensions or compressions due to overturning moment of the bent as a whole; *c*, longitudinal stresses due to bending moment acting upon the individual column.

2. Longitudinal tensions or compressions in the knee braces.

3. Longitudinal tensions or compressions in the members of the truss proper.

Evidently the truss proper cannot resist the wind pressure without the action of the columns. The latter carry all the force of the wind to the foundations, where the ultimate resistance is exerted. Hence it is logical, as well as convenient, to turn to the columns first, and the truss afterward, in determining the stresses in the bent.

The forces exerted by the tops of the columns and by the knee braces, and the wind pressure upon the truss, may be considered as a set of external forces held in equilibrium through the medium of the stresses in the truss.

The total of the final resistant at the feet of the columns is readily found from the fact that the algebraic sum of all the horizontal forces acting upon the truss is zero; Σ hor. forces = zero.

With this final resistant computed one has at hand all the data that are necessary for obtaining the relations and amounts of the stresses in and the forces acting directly upon the columns. It is only a step from these to the forces acting upon the knee braces, and then finally, to the forces acting upon the truss proper.

Thus will have been obtained all the external forces acting upon the truss proper, from which the path is simple and direct, by the ordinary methods of statics, to the stresses in the members of the truss.

THE COLUMNS (PRELIMINARY).

The forces acting on the pair of columns of one bent are fully, illustrated in Figure 3. K denotes the stress in the knee brace and L and R those in the lower chord and rafter of the truss respectively.* V_a denotes the vertical reaction at foot of column

* Whenever a designating letter is given in the text without the subscript 1, or 2, it is understood that the remarks apply equally to both columns.

due to the tendency of the bent to overturn about the foot of the leeward column.

The value of V_a can be obtained from a simple equation of moments which will be given in due course. V_c denotes the vertical component of R, and is the same as the vertical action of the truss proper upon the top of the column. Its value can be found as follows: V_a+V_c=vert. component of K, $\therefore$ V_c=vert. comp. of K—V_a.

K, R, and L are unknown and, to ascertain their values there is involved the resistance of the columns to lateral flexure when considered as vertical beams horizontally loaded. The forces which may be said to cause this lateral flexure are the resultant horizontal components A, B, and C of the three groups of forces acting upon the column at the points *a*, *b*, and *c* (see Fig. 4).

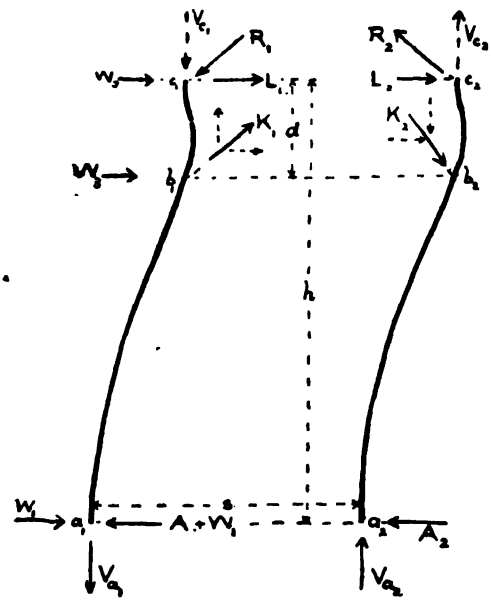


FIG. 3.—The Forces acting on a pair of columns.

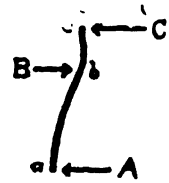


FIG. 4.—Resultant horizontal components acting on one column.

Of these three resultant horizontal components A is known at once, as it represents the ultimate horizontal resistance to the wind at the foundations of the columns. The value of A for each column can be obtained from the equation, (see Fig. 3), $A_2+A_1+W_1=2\ A_1+W_1=\Sigma W$, $\therefore$ $A_1=\frac{1}{2}(\Sigma W-W_1)$; that is, *the value of A*

*equals one-half the result obtained by subtracting the wind concentration at the foot of the windward column form the total horizontal wind pressure on one bay of the building from the base to ridge of roof.**

$C_1=C_2$, denotes the resultant of the horizontal components of all the forces acting upon the column at the top, the point *c*.

$B_1=B_2$, denotes the similar resultant for all the forces acting at *b*, the point of connection of the foot of the knee brace. A being known, the values of B and C can be found, provided the ratios which they bear to the value of A are known. These ratios depend *solely* upon the laws of flexure of the column considered as a beam transversely loaded, and therefore vary with the theoretical character of support of the ends of this beam. They are entirely independent of the system of construction of the building as a whole, varying only with the conditions of theoretical design at the ends of the columns.

The ratios of B and C to A are different, for example, in the case of columns rigidly fixed at the ends from what they are if the columns are pinned. In another place these ratios will be given in detail for the different cases that may arise in practice.

The values of B and C for any particular condition of column connections having been found, B_2= hor. comp. of K_2, and $B_1—W_2$ = hor. comp of K_1; (see Fig. 3), from which K_1 and K_2 can be readily computed. Also their vertical components may be found at the same time. Analogy would dictate at this point that the discussion be carried to completion, and, knowing C_1 and C_2, it be explained how the valves of R and L are found. A violation of consistent treatment is here justified however, as R and L are stresses in the truss proper, and are more readily handled when treating the truss itself.

THE TRUSS PROPER (PRELIMINARY).

The forces acting upon the columns being known, it is a direct step to the forces acting on the truss. As C_1 and C_2 are the resultant horizontal components of all the forces acting upon the tops of the columns, it follows that *the tops of the columns exert*

* Strictly speaking, if the framing of the side wall is so constructed that the side pressure on the windward wall is distributed uniformly all along the length of the column, the wind concentration at the foot of the column should not be deducted, but the side framing is usually such as to justify the above rule.

equal but directly opposed resistances, C_1 *and* C_2, *at the ends of the truss.* The case is analogous for V_{c1} and V_{c2}; likewise for the actions, K_1 and K_2, of the knee braces, in case the latter are used. The wind concentrations upon the truss have, of course, been already

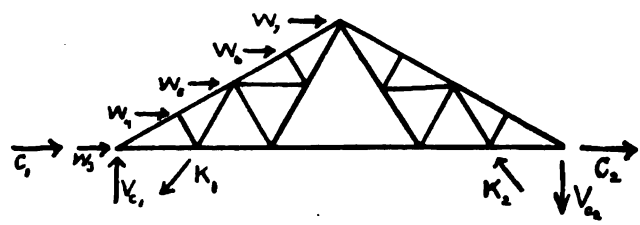


FIG. 5.—The External Forces acting on the Truss.

computed. Thus are known all the external forces acting upon the truss, (see Fig. 5). Having determined all the external forces a simple force polygon will give the internal stresses in the truss members.

DETAILED DISCUSSION.

It is apparent from what has preceded that the outlines of the process are:

1st. The treatment of the columns, in which the object is:

a. To determine the internal stresses acting in the columns themselves.

b. To find the values of the external forces acting upon the truss proper.

2d. The treatment of the truss proper to find the internal stresses in its members.

THE COLUMNS (DETAILED).

The preliminary discussion makes it evident that the primary step in treating the columns is to determine the values of A, B, and C, the resultant horizontal components of the external forces acting upon the column at the foot, point of connection of the knee brace and top of the column, respectively. These points are lettered *a*, *b* and *c*. The value of A depends upon the vertical elevation of the building and the wind pressure and its computation is a matter of simple arithmetic. (see p. 239.)

The ratios of B and C to A depend upon the laws of flexure,

and vary with the manner in which the ends of the columns are connected.

THE VALUES OF A, B, AND C.

The following discussion is for the purpose of establishing the expression for the ratios of A, B, and C, and the resulting formulæ, for all conditions that arise in practice. There are several cases that are possible, according as the bents have or have not knee braces, and according as the columns are or are not rigidly connected at the top and base. If they are rigidly connected at the ends; that is, in such a manner that the connection is capable of resisting the full bending strength of the column at the ends, the column may be considered and treated as a beam "restrained" or fixed at the ends.

If the column is not so connected, but is bolted or riveted merely for the purpose of keeping it in place, it must be considered and treated as a beam "simply supported" or pinned at the ends.

The cases that may occur will now be stated, and the series of formulæ given that apply to these cases. They are not all of equal importance, as some of the cases are rarely met in practice. Their relative importance, and the conditions under which it is proper to use the formulæ of one case or the other will be explained presently.

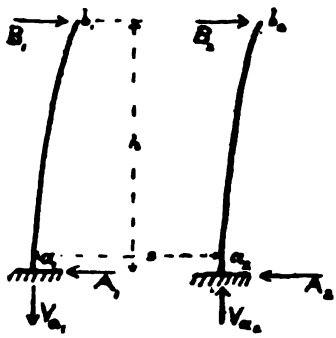
The following pages of mathematics have been condensed to the utmost, and are given, although with regret, because they are necessary to a complete presentation of the subject. If one is disposed to do so he can pass them by without entirely losing the line of thought, referring back to the formulæ as may be desired.

The columns are considered as vertical beams, horizontally loaded at the points *a*, *b*, and *c*, and the formulæ are based upon the theory of flexure.* Preliminary to the formulæ, in all the cases, is the simple arithmetical relation $A_1=A_2=\frac{1}{2}(\Sigma W-W_1)$, (see p. 239.)

* Several of these formulæ are of every day familiarity, but others are rarely used, or seen in print. It would unduly lengthen the text to give in this connection a series of experiments upon beams made by the writer with a view to testing certain of the formulæ. The experiments are of interest in that they confirm from a practical standpoint the correctness of the theoretical treatment. Reference is made to the *Engineering Record* of June 29 and August 24, 1895, and to the Journal of the Franklin Institute for July, 1895, in which will be found descriptions of these tests.

All similar forces on the two columns are equal; $B_1 = B_2$, $C_1 = C_2$, and so forth, hence, in what is to follow, subscripts will be omitted. When a letter common to the two columns is used to represent a force it will be understood to apply to either column.

Case A—1.



Conditions.

No knee braces.
Columns fixed at base.
Columns pinned at top.
Column acts as a cantilever beam fixed at *a* and free at *b*.

Formulæ.

B=A.

x denotes the vertical distance from b.

M_x denotes bending moment at distance x.

$M_x = Bx$.

$M_{base} = Bh$.

M_{top} = zero.

Σ W denotes the total wind pressure on one bay of the building from foot of column to ridge of roof.

l denotes height from foot of column to ridge of roof.

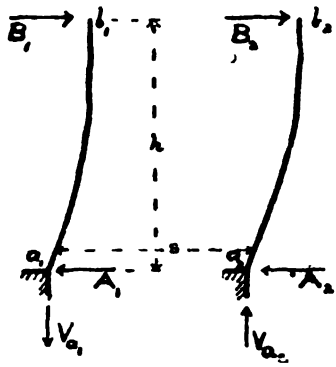
$V_a = \frac{1}{c} [\Sigma W \times \frac{1}{2}l - 2Bh.]$

This equation is apparent from the following reasoning. The bent, as a whole, tends to rotate about a_2, because of the wind pressure. The rotating moment is the sum of each wind concentration multiplied by its lever arm about a_2, $= \Sigma W \times \frac{1}{2}l$. The resisting moments are the resistant moments, $M_{base\,1}$ and $M_{base\,2}$, exerted by the columns in the plane of the bent and contrary to the wind moment, and the moment of the vertical reaction V_{a1} at a_1,

Hence $o = \Sigma W \frac{1}{2}l - 2M_{base} - V_{a\,1}r$.

This transforms into the above equation.

Case A—2.



Conditions.

No knee braces.

Columns pinned at base.

Columns fixed at top; *i. e.*, free to move laterally at top, but restrained so that tangent to axis at top remains vertical.

Columns act like a cantilever beam restrained at *b* and free at *a*.

Formulæ.

B=A.

$M_x = A(h-x)$ (see Case A—1).

Max. bending moment, denoted by M_{top}, is at *b*.

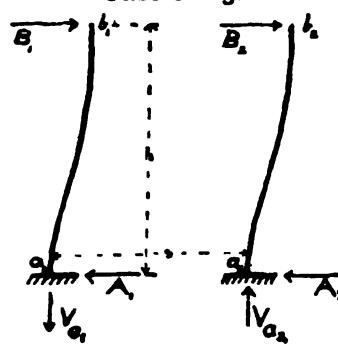
$M_{top} = Ah$.

M_{base} = zero.

$V_a = \frac{1}{l}[\Sigma W \frac{1}{2} l - 2M_{top}] = \frac{1}{l}[\Sigma W \frac{1}{2} l - 1Ah]$.

This equation is apparent from the reasoning of Case A—and 1, from the fact that the columns exert at their tops resistant moments, $M_{top\,1}$, and $M_{top\,2}$, in the plane of the bent, with a tendency of rotation contrary to that of the wind pressure about a_2.

Case A—3.



Conditions.

No knee braces.

Column fixed at base.

Columns fixed at top; *i. e.*, free to move laterally at the top, but restrained so that tangent to axis at top remains vertical.

Columns act like a cantilever beam fixed at *a* and free at *b*.

Formulæ.

B=A.

$M_x = B(x - \frac{1}{2}h)$.

Max. bending moment is at *a* and also at *b*.

$M_{base}=M_{top}=\frac{1}{2}Bh=\frac{1}{2}Ah.$

$V_a=\frac{1}{s}[\Sigma W\frac{1}{2}l-2M_{base}-2M_{top}]=\frac{1}{s}[\Sigma W\frac{1}{2}l-2Ah]$ (see cases A—1, and A—2).

Demonstration of Formulæ.

Conditions are:

Origin of coördinates is at *b*.

Axis of X is vertical.

$\frac{dy}{dx}$=zero for $x=o$ and for $x=h$.

(1) $M_x=EI\frac{d^2y}{dx^2}=-M_{base}+Bx.$

(2) $EI\frac{dy}{dx}=-M_{base}\,x+\frac{1}{2}Bx^2+Con_1$

(3) $EIy=-\frac{1}{2}M^{base}\,x^2+\frac{1}{6}Bx^3+Con_1x+Con_2$

For $x=o$ $\frac{dy}{dx}=o$, hence $Con_1=o$.

Fox $x=o$ $y=o$, hence $Con_2=o$.

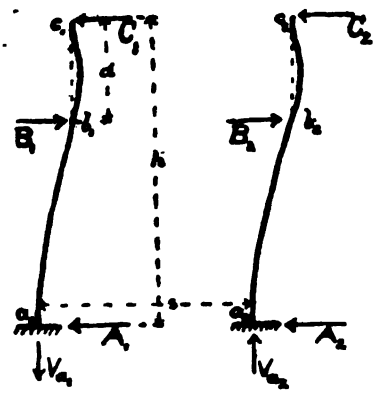
Making $x=h$ in equation (2) and reducing,

$M_{base}=\frac{1}{2}Bh.$

Introducing this value in equation (1) and making $x=o$.

$M_{top}=-\frac{1}{2}Bh.$

Case B—1.



Conditions.

Knee braces connected to columns at b_1 and b_2.

Columns fixed at base.

Columns fixed at top; *i. e.*, free to move laterally at top, but restrained so that tangent to axis at top remains vertical.

Columns held by knee brace at *b* and truss at *c*, so that points *b* and *c* remain in a vertical line.

The column acts like a cantilever beam fixed at *a*, and deflecting under the action of the forces C and B.

Formulæ.

$C=\frac{1}{2}A\frac{(h-d)^2}{d(\frac{2}{3}h-\frac{1}{2}d)}$

$B=A+C.$

Above point b the max. bend. moment occurs at the top of column, and at distance *d* from top, and equals $\frac{1}{3}Cd$ and—$\frac{2}{3}Cd$ respectively.

$M_x = C(\frac{1}{3}d - x)$

Below point b the max. bend. moment occurs at the foot of the column.

$M_{base} = h(B - C) - d(B - \frac{1}{3}C)$.

$M_x = C(\frac{1}{3}d - x) + B(x - d)$.

$V_a = \frac{1}{a}[\Sigma W \frac{1}{2}l - 2M_{base} + 2M_{top}] = \frac{1}{a}[\Sigma W \frac{1}{2}l - 2h(B - C) + 2d(B + \frac{1}{6}C)]$

The resistant moments, $M_{top\,1}$ and $M_{top\,2}$ exerted by the columns at their tops have the same tendency of rotation as that of the wind pressure about a_2, while those at the bases of the columns have a contrary tendency; (see Case A—1).

Demonstration of Formulæ.

Conditions are:

Origin of Coördinates is at C.

Axis of X is vertical.

$y = o$ for $x = o$, and for $x = d$.

$\frac{dy}{dx} = o$ for $x = o$, and for $x = h$.

A—B+C—zero.

Above point b.

(1) $M_x = EI\frac{d^2y}{dx^2} = M_{top} - Cx$.

(2) $EI\frac{dy}{dx} = M_{top}x - \frac{1}{2}Cx^2 + Con_1$.

(3) $EIy = \frac{1}{2}M_{top}x^2 - \frac{1}{6}Cx^3 + Con_1x + Con_2$.

$\frac{dy}{dx} = o$ for $x = o$, hence, in (2), $Con_1 = o$.

$y = o$ for $x = o$, hence, in (3), $Con_2 = o$.

As $y = o$ for $x = d$, it follows from (3) that

$M_{top} = \frac{1}{3}Cd$.

Below point b.

(1)^1 $M_x = EI\frac{d^2y}{dx^2} = M_{top} - Cx + B(x - d) = \frac{1}{3}Cd - Cx + B(x - d)$.

(2)^1 $EI\frac{dy}{dx} = \frac{1}{3}Cxd - \frac{1}{2}Cx^2 + \frac{1}{2}Bx^2 - Bxd + Con_3$.

(3)^1 $EIy = \frac{1}{6}Cx^2d - \frac{1}{6}Cx^3 + \frac{1}{6}Bx^3 - \frac{1}{2}Bx^2d + Con_3x + Con_4$.

$\frac{dy}{dx} = o$ for $x = h$, hence, in equation (2)^1,

$Con_3 = hd(B - \frac{1}{3}C) - \frac{1}{2}h^2(B - C)$.

$y = o$ for $x = d$, hence in equation (3)^1, $Con_4 = -\frac{1}{2}h^2d(B - \frac{1}{3}C) + \frac{1}{3}h^3(B - C)$.

Introducing the terms already found, the two series of equations reduce to:

Above point b.

(1) $M_x = EI\frac{d^2y}{dx^2} = \frac{1}{3}Cd - Cx$.

(2) $EI\frac{dy}{dx} = \frac{1}{3}Cxd - \frac{1}{2}Cx^2$.

(3) $EIy = \frac{1}{6}Cx^2d - \frac{1}{6}Cx^3$.

Below point b.

$(1)^1\ M_x = EI\frac{d^2y}{dx^2} = \frac{1}{3}Cd - Cx + Bx - Bd.$

$(2)^1\ EI\frac{dy}{dx} = (B-C)\frac{1}{2}(x^2 - h^2) + (B - \frac{1}{3}C)\,d(h - x).$

$(3)\ EIy = (B-C)\frac{1}{6}[x^3 - 3h^2(x-d)] + (3B-C)\,\frac{d}{6}[-x^2 + 2h(x-d)] + \frac{B}{3}d^3.$

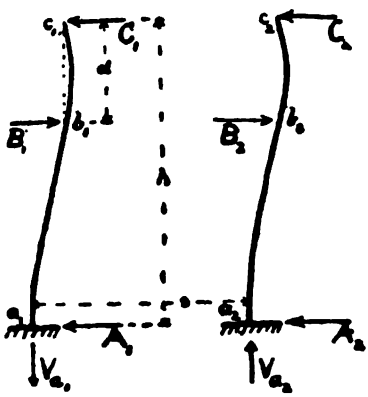
The two curves of deflection have a common tangent at b; hence, making $x = d$, and combining equations (2) and $(2)^1$, $-\frac{1}{6}Cd^2 = -\frac{1}{2}Cd^2 + \frac{1}{2}Ch^2 - \frac{1}{3}Cdh + \frac{1}{3}Cd^2 + \frac{1}{2}Bd^2 - \frac{1}{2}Bh^2 + Bdh - Bd^2$. Also $B = A + C$. Introducing this value of B, reducing, and solving for C,

$$C = \frac{1}{2}A\,\frac{(h-d)^2}{d(\frac{2}{3}h - \frac{1}{2}d)}$$

Making $x = h$ in equation $(1)^1$ and reducing,

$M_{base} = h(B-C) - d(B - \frac{1}{3}C).$

Case B—2.



Conditions.

Knee braces connected to the columns at b_1 and b_2.

Columns fixed at base.

Columns pinned at top; *i. e.*, free to deflect at top like a beam "simply supported" at the ends; also free to move laterally at the top.

Columns held by knee braces at b and by truss at c, so that points b and c remain in a vertical line.

The column acts like a cantilever beam fixed at a and deflecting under the action of forces C and B.

Formulæ.

$$C = \frac{1}{2}A\,\frac{(h-d)^2}{d(h - \frac{2}{3}d)}$$

$B = A + C.$

Above point b the max. bend. moment occurs at the distance d from top, and equals Cd.

$M_{top} =$ zero.

$M_x = Cx.$

Below point b the max. bend. moment occurs at the foot of the column.

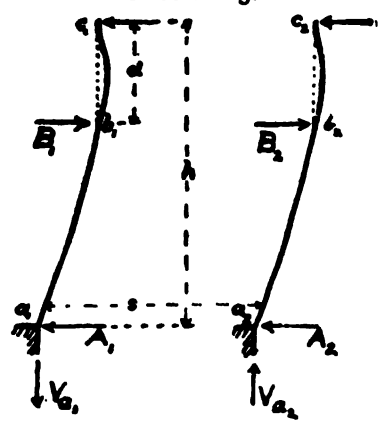
$M_{base} = h\,(B-C) - d\,B.$

$M_x = -Cx + B\,(x-d).$

$V_a = \frac{1}{a}[\Sigma W \frac{1}{2}l - 2M_{base}] = \frac{1}{a}[\Sigma W \frac{1}{2}l - 2h(B-C) + 2d\,B].$

The demonstration of the formulæ is entirely similar to that given for Case B—1, and hence is omitted.

Case B—3.



Conditions.

Knee braces connected to columns at b_1 and b_2.

Columns pinned at base.

Columns fixed at top; *i. e.*, free to move laterally at top, but restrained so that tangent to axis at top remains vertical.

Columns held by knee brace at b, and truss at c, so that points b and c remain in a vertical line.

The column acts like a cantilever beam fixed at c and free to deflect under the action of forces A and B.

Formulæ.

$C=-\frac{3}{2}A\frac{h-d}{d}$

$B=A+C.$

Above point b the max. bend. moment occurs at the top of column, and at the distance d from the top, and equals $+\frac{1}{3}\,Cd$ and $-\frac{2}{3}\,Cd$ respectively.

$M_x=C\,(\frac{1}{3}d-x).$

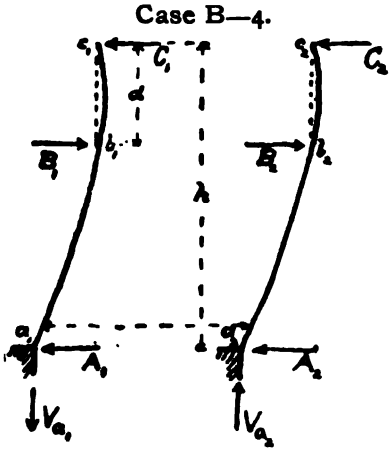
Below point b the max. bend. moment occurs at b and equals $\frac{2}{3}\,Cd.$

$M_x=C\,(\frac{1}{3}d-x)+B(x-d).$

$V_a=\frac{1}{c}[\Sigma W\frac{1}{2}l+2\,M_{top}]=\frac{1}{c}[\Sigma W\frac{1}{2}l+\frac{2}{3}\,Cd].$

The demonstration of the formulæ is entirely similar to that given for case B—I, and hence is omitted.

Case B—4.



Conditions.

Knee braces connected to the columns at b_1 and b_2.

Columns pinned at base.

Columns pinned at top; *i. e.*, free to deflect at top, like a beam "simply supported" at the ends; also free to move laterally at the top.

Columns held by knee brace at b and by truss at c, so that points b and c remain in a vertical line.

The column acts like a beam supported at *b* and deflecting freely under the action of the loads A and C, which are balanced over the fulcrum *b*.

Formulæ.

$C = A\frac{h-d}{d}$

$B = A + C.$

Above point b the max. bend. moment occurs at distance *d* from top of column, and equals C*d*.

$M_{top} = \text{zero.}$

$M_x = Cx$, (*x* denoting the distance from top of column).

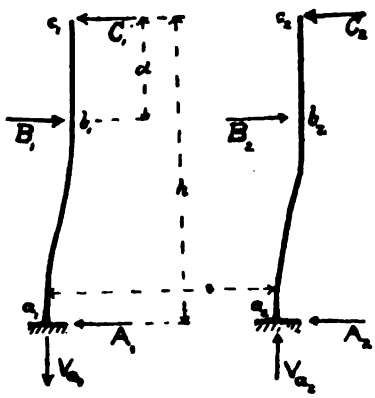
Below point b the max. bend. moment occurs at *b*, and equals C*d*.

$M_{base} = \text{zero.}$

$M_x = Cx - B(x - d).$

$V_a = \frac{1}{d} \Sigma W \frac{1}{2} l$

Case C—1.



Conditions.

A stiffened gusset plate between truss and column, riveted to column from *b* to *c*, thus holding the column in a straight line from *b* to *c*, so that there is no bending in it above point *b*.

Columns fixed at base.

Columns free to move laterally at top, but restrained so that tangent to the axis at *b* remains vertical.

Columns held by gusset plate and by truss so that points *b* and *c* remain in a vertical line.

The column acts like a cantilever beam of the length *h*—*d*, fixed at *a* and deflecting under the action of the forces B and C.

Formulæ.

$C = \frac{1}{2} A\frac{h-d}{d}$

$B = A + C$

Above point b there is, from the nature of the conditions, no bending moment, hence $M_{top} = \text{zero.}$

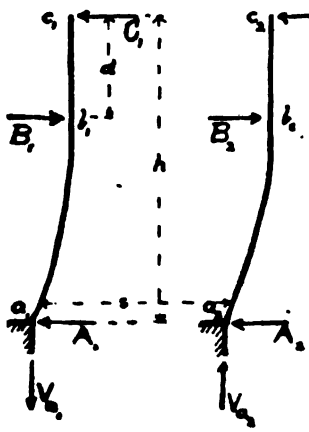
Below point b the max. bend. moment occurs at *b* and at *a*, and equals—Cd and + Cd respectively, equals —or + ½ A (*h*—*d*)

$M_x = (B—C)\,x—Bd$

$V_a = \frac{1}{s}\,[\Sigma W\, ½\, l—2\, M_{base}] = \frac{1}{s}\,[\Sigma W\, ½\, l—A\,(h—d)]$

As M_{top} = zero there is no resistant moment at the top of the column; hence the above equation. The demonstration of the formulæ is entirely similar to that for Case B—1, and consequently is omitted.

Case C—2.



Conditions.

A stiffened gusset plate between truss and column, riveted to column from *b* to *c*, thus holding the column in a straight line from *b* to *c*, so that there is no bending in it above point *b*

Columns pinned at base.

Columns free to move laterally at top, but restrained so that tangent to the axis at *b* remains vertical.

Columns held by gusset plate and by truss so that points *b* and *c* remain in a vertical line.

The column acts like a cantilever beam of the length *h*—*d*, fixed at *b* and deflecting under the force A.

$C = A\,\frac{h-d}{d}$

$B = A + C$

Above point b there is no bending moment, hence M_{top} equals zero.

Below point b the max. bend. moment occurs at *b* and equals A (*h*—*d*).

M_{base} = zero.

$M_x = A\,(h—x.)$

$V_a = \frac{1}{s}\,\Sigma W\, ½\, l.$ (See case C—1.)

The demonstration of the formulæ is entirely similar to that of Case B—1, and consequently is omitted.

REMARKS UPON THE VARIOUS CASES.

One of the conditions in the two series of cases "B" and "C" is that point *b* is held vertically under point *c* by the rigidity of

the truss and knee brace. There is a series of cases similar to those just given, except that the point *b* is, during deflection, at some distance to the right or left of the vertical through the point *c*. These cases are incapable of solution unless the amount of offset of point *b* from the vertical through *c* is known. They are not of importance to this discussion because it is reasonable to assume that the truss is sufficiently rigid to maintain itself during the deflection of the bent in a position parallel to its normal position, in which case the points *b* and *c* will remain in a vertical line. It is entirely conceivable that the truss might be designed with so much of a curve in its lower chord that it would be temporarily distorted under wind pressure, and thus throw point *b* out of the vertical through *c*. It is theoretically possible to compute this distortion and then obtain the ratio of the horizontal components B and C to A, as in the cases already given. A truss of this nature, however, would more properly be designed like the modern curved truss of a train shed, and, being of the arch type, should be treated according to the laws governing that class of structures.

In the theoretical deduction of the formulæ the columns were considered as either "fixed" or "pinned" at the ends. The term fixed is intended to cover those cases in which the column is so rigidly attached at the end to the foundation or truss as to develop the full resistant moment of the column against bending; or, in other words, so that the tangent to the curve of deflection at the end of the column shall remain vertical. In actual design the column is rarely pinned, strictly speaking, at either end, but the term is retained nevertheless, to provide for those cases in which the connection is insufficient to develop the full resistant moment of the column at the end, and, as a consequence, the column deflects from the vertical at the end.

The table on page 252 gives the resulting stresses due to vertical load and wind pressure under all the cases A—1 to C—2 inclusive for a bent of a particular building. (See illustration in Fig. 7).

A comparison of these resulting stresses affords the following generalizations. The greatest stresses throughout the entire truss and the knee braces are caused by the condition of case B—3, in which the columns are fixed at top and pinned at base.

The minimum stresses—not necessarily minimum in the columns—are caused by the conditions of the A series, in which no knee braces are used, and by the conditions of case B—2, in which

COMPILATION OF STRESSES FOR THE FRAME SHOWN IN FIGURE 7.

The stresses are given for all the various conditions as to the use or absence of knee braces and gusset plates, and the different assumptions regarding the connections at the ends of the columns. The data upon which the calculations are based are given on page . + denotes tension and — denotes compression. All forces are given in pounds.

Designation of Member of Truss, Bending Moment, Etc.	Stresses Due to Dead Load.	Case A—1. No knee braces Cols. plnned at top. Cols. fixed at base.		Case A—2. No. knee bra. Cols. fixed at top. Cols. pinned at base.		Case A—3. No. knee bra. Cols. fixed at top. Cols. fixed at base.		Case B—1. Knee braces (2 L's.). Cols. fix'd at top. Cols. fixed at base.		Case B—2. Knee braces (2 L's.). Cols. pinned at top. Cols. fixed at base.		Case B—3. Knee braces (2 L's.). Cols. fixed at top. Cols. pinned at base.		Case B—4. Knee braces (2 L's.). Cols. pinned at top. Cols. pinned at base.		Case C—1. Cols. stfn'd. by gussets from ft. of bra. up. Cols. pinned at top. Cols fix'd at ba.		Case C—2. Cols. stiffened by gussets from ft. of brace up. Cols. pinned at top. Cols. pinned at base.	
		Wind Load.	Max. + or —	Wind Load.	Max. + or —	Wind Load.	Max. + or —	Wind Load.	Max. + or —	Wind Load.	Max. + or —	Wind Load.	Max. + or —	Wind Load.	Max. + or —	Wind Load.	Max. + or —	Wind Load.	Max. + or —
Bend. Moment at top of Column (ft. lbs.)		Zero	Zero	334100	334100	167100	167100	46800	46800	Zero	Zero	109700	109700	Zero	Zero	Zero	Zero	Zero	Zero
Bend. Moment at Base of Column (ft. lbs.)		334100	334100	Zero	Zero	167100	167100	125900	125900	130300	130300	Zero	Zero	Zero	Zero	109700	109700	Zero	Zero
External Force $C_1 = C_2$ (hor. at top of Column),		12850	12850	12850	12850	12850	12850	13250	13250	8410	8410	31050	31050	20700	20700	10350	10350	20700	20700
External Force K_1 (Stress in Knee Brace),		.....	.....	.....	.....	.....	.....	29140	29140	22300	22300	54310	54310	39680	39680	25040	25040	39680	39680
External Force K_2 (Stress in Knee Brace),		.....	.....	.....	.....	.....	.....	38890	38890	32040	32040	64050	64050	49420	49420	34780	34780	49420	49420
External Force Vc_1 (Vert. at left end of truss),		3940		3940		3940		10650		7020		24000		16240		8420		16240	
External Force Vc_2 (Vert. at right end of truss),		3940		3940		3940		17540		13910		30890		23130		15310		23130	
R_1 (Rafter, Left Hand),	—31800	+ 7100	—31800					—19100	—50900	—12600	—44400	—43200	—75000	—29100	—60900	—15100	—46900		
R_2 " " "	—31800	+ 2500	—31800					—23700	—55500	—17100	—48900	—47700	—79500	—33700	—65500	—19600	—51400		
R_3 " " "	—31800	— 800	—32600					— 8700	—40500	— 6400	—38200	—16600	—48400	—11700	—43500	— 6900	—38700		
R_4 " " "	—31800	— 5400	—37200					—13200	—45000	—10900	—42700	—21300	—53100	—14100	—45900	—11500	—43300		
													—31800		—31800				
R_5 " Right "	—31800	— 7100	—38900					+31600	—31800	+25000	—31800	+55600	+23800	+41500	+ 9700	+27600	—31800		
R_6 " " "	—31800	— 7100	—38900					+ 6800	—31800	+ 4700	—31800	+ 15100	—31800	+10100	—31800	+ 5400	—31800		
L_1 (Lower Chord, Left Hand),	+ 26400	— 1800	+26400					— 2000	+26400	— 2500	+26400	+ 200	+26600	+ 1200	+26400	— 1600	+22600		
L_2 " " " "	+ 22600	— 3700	+22600					+ 4000	+22600	— 500	+22600	+ 8000	+30600	+ 4000	+26600	+ 200	+15300		
$L_{3\text{ to }6}$ " " " "	+ 15100	— 7000	+15100					— 9700	+15100	— 1700	+15100	— 9700	+15100	— 9700	+15100	— 9700	+ 5400		
													— 500						
L_8 " " Right "	+ 26400	— 7000	+26400					—13900	+26400	— 2400	+26400	—26900	+26400	—13900	+26400	—12600	+26400		
									— 100						— 100				
L_7 " " " "	+22600	— 7000	+22600					—22700	+22600	— 8000	+22600	—15200	+22600	—22700	+22600	—18800	+22600		
D_1 (Diagonal, Left Hand),	+ 6300	+ 3200	+ 9500					+38100	+44400	+ 2900	+29200	+51200	+57500	+38100	+44400	+25200	+31500		
D_2 " " "	+ 12500	+ 5500	+18000					+22900	+35400	+15300	+27800	+29700	+42200	+22900	+35400	+16500	+29000		
									—37200		—22000		—50100		—37200		—24500		
D_3 " Right "	+ 6300	Zero	+ 6300					—43500	+ 6300	—28300	+ 6300	—56400	+ 6300	—43500	+ 6300	—30800	+ 6300		
									— 9200		— 1600		—16100		— 9300		— 2900		
D_5 " " "	+ 12500	Zero	+ 12500					—21700	+ 12500	—14100	+ 12500	—28600	+ 12500	—21800	+ 12500	—15400	+ 12500		
P_2 (Vertical, Left Hand),	—10100	— 4400	—14500					—18300	+ 28400	—12300	—22400	—23700	—33800	—18300	—28400	—13200	—23300		
									—10100		—10100		—10100		—10100		—10100		
P_6 (Vertical, Right Hand),	—10100	Zero	—10100					+ 17400	+ 7300	+ 11300	+ 1200	+ 22900	+ 12800	+ 17400	+ 73 00	+ 12400	+ 2300		

Same as Case A—1. Same as Case A—1. Same as Case B—4.

the columns have knee braces, and are pinned at the top and fixed at the base.

Case B—4 gives the stresses next to the maximum, and the conditions of that case are that both ends of the column are pinned. Cases C—2 and B—4 give equal stresses throughout.

Case C—1 gives the stresses next to the minimum. In this case the columns are fixed at the base and gusset plates are used, stiffening the upper end of the column. Case B—1, in which the conditions are that the columns are fixed at both ends, is the one in the B series next to the minimum. The stresses for this case are the same as for Case B—4, in which the columns are pinned at both ends, except for certain panels of the rafters where the stresses are less in amount than for Case B—4.

The A series of cases causes decidedly small stresses in the members of the truss as compared with the B and C series, but it is at the expense of the column connections, which are subjected to bending moments that are practically prohibitive, and also, with the penalty, in Cases A—2 and A—3, of severe secondary stresses in the members of the truss at its ends.

No reversals of stress under the action of wind pressure occur in the A series of cases, but several of considerable importance are noticeable in the B and C series, particularly in the diagonal and vertical braces of the truss. The bending moments at the ends of the columns are greatest for the A series, especially when the columns are fixed at one end only. For the B series and C series the bending moment is about the same in amount whether the columns are fixed at the top or at the base.

In case B—2, in which both ends of the column are pinned, all bending moment is, of course, eliminated from both ends of the columns.

It is obvious from the above, as well as from independent reasoning, that the more the effect of lateral pressure is concentrated as bending moment at the bases of the columns, and the more the tops of the columns are freed from bending moment, the smaller will be the stresses throughout the superstructure.

Practical Conclusions.

The foregoing discussion of the various cases has been based upon purely theoretical considerations, and judgment should be used in making a practical application of it. The cases A—1 to

C—2 inclusive are of greatly different importance, and certain of them are rarely, if ever, encountered in actual construction.

The A series, in which knee bracing is omitted, finds application only to relatively unimportant buildings. There can be no question of the advantage, and even necessity of using knee braces in "mill construction" exposed to wind pressure, except for small, low, or merely temporary structures. In the majority of cases in which knee braces are omitted the building is insecure against anything approaching a pressure of, say, thirty pounds per square foot upon its sides and roof. The fact that there are such buildings standing is no proof of their security, and whatever force it has is offset by the many buildings of this weak construction which have ultimately to be reinforced and braced laterally. The absence of knee braces assumed in the A series causes reduced stresses in the members of the truss as compared with the B and C series, but it is at the expense of very considerable bending moment at the ends of the columns. The objection to designing in such a way as to develop a large bending moment at the top of the column is not entirely on account of the column itself. The disadvantage lies in the excessive secondary stresses that a large bending moment causes in the members of the truss at the connection, and in the difficulty of making a proper connection with the end of the truss. It is not always easy, without elaborate and expensive connections, to properly provide for resisting this bending moment. For example, supposing that the bending moment at the top of the volume is 50,000 foot pounds, a simple estimate for a very common form of connection shows at once that if the truss is to be held down to an ordinary sized cap plate by rivets or bolts, three to four square inches of cross section may be required in the rivets or bolts, and this even when assuming a tension as great as 20,000 pounds per square inch in the material.

The use of the knee braces meets the difficulty in a satisfactory manner. But it is evident that the knee brace must not be looked upon—and this is too often the case—in the light of a mere appendage, added to the general design as a more or less superfluous safeguard, or merely to stiffen the structure against vibration.

In that event it will probably not be designed to meet any definite stress, and its connections will be weak. A computation of the actual stresses shows the error of such a course, for the

presence of the knee brace increases the stresses in certain members, and it is itself subjected to a stress only exceeded in the case of a few principal members of the truss. For example, the case computed in this paper and given in the table on page 252, shows that the stress in the knee braces due to wind alone is only exceeded in the entire truss by the stresses in two panels of the rafter, and those the combined effect of wind and dead load.

Gussets, consisting of triangular plates fitted into the corners between the truss and the columns and stiffened with angle irons, are more effective but also more expensive than the ordinary knee brace. It cannot be questioned that they are in theory a better design than the pair of angle irons bent at the ends which constitute the usual knee brace. Gusset plates make a very firm, stiff connection admirably well adapted to resist vibrations, and, although they involve the use of more metal and work, greater accuracy of shop work, and more shop and field riveting than does the ordinary knee brace, it is good practice to use them in many designs.

Turning to the consideration of the ends of the columns, the theoretical condition of the end of the column known as "fixed" presupposes such a rigid connection as to hold the column absolutely vertical at the end under the action of the maximum lateral wind pressure. Now, in reality the columns are rarely so connected as to be fixed at the ends within this strict meaning of the term, and the amount of possible end deflection may easily be enough to destroy the condition of rigidity. Hence, it is usually proper to consider the columns as "pinned" at the ends, even if they do not have actual pin bearings.

Thus, at the top, the column is generally capped by a plate upon which the truss rests and is held in place by two 1¼-inch bolts, or possibly an expansion joint is introduced. Rarely is the truss rigidly attached to the end of the column with a system of splices and rivetting at all adequate to develop anything like the full resistant moment of the end of the column.

At its base the column may be merely held down to a timber string piece by two angle lugs riveted to the web of the column and lag screwed fast to the timber. No word of comment is necessary concerning the amount of resistance to bending moment afforded by such a connection.

Then, again, the footing of the column may consist of quite a substantial looking construction, angle lugs being used to connect

the column with a bed plate, and the latter anchored with two or four bolts through a heavy capstone into a masonry pier. If, however, the lugs are riveted to the column near its neutral axis they offer very little resistance to bending moment, and it is rare in any case to find them equal to developing the full strength of the column in this respect. In fact, in order to accomplish this in some cases it may be necessary to put on bracket plates extending two feet or more up the column and widening out its footing. In addition to this there must be considered the possibility of the column rotating the entire masonry pier about some point of its base.

It is entirely possible to design the footing so as to develop the full resistant moment of the column, and in some instances this is done, in which case one is justified in considering the column as "fixed" at the base, but caution should be used in applying this assumption, even to column which appears to have a considerable degree of rigidity. The assumption that the base is pinned is always on the side of safety.

The B series of cases, involving the use of knee braces, include the structures most frequently found in practice. Case B—4 *is the proper one to apply in calculating the stresses for the great majority of designs in which knee braces are used.*

This case supposes the columns pinned at both ends. It has just been explained that this supposition is in closer accord with the actual conditions than any other for nearly all designs. This is because of the lack of strength in the connection at the end of the column to develop the full resistant moment of the column, and also because, even where there is considerable ultimate strength in the connection, there may be sufficient play to allow a slight deflection of the column at the end in spite of the ultimate rigidity of the connection. This tends immediately to place the conditions under class B—4.

Case B—2 comes next in frequency in actual design. It assumes the columns rigid at the base and pinned at the top. It is a good design, so far as the strength of the superstructure is concerned, but requires expensive footings for the columns. The diminished stresses in and consequently smaller sizes of the truss members caused by this design may go far to balance the outlay upon foundations and footings, but it should not be overlooked that any subsequent tendency to rocking in the footings increases the possible

stresses in the truss members beyond what they were designed to meet.

The use of Case B—1, in which both ends of the column are fixed, is justified in certain instances of rigid, firm construction.

If the columns are really fixed at the top this case certainly should be used, for with it greater stresses are obtained than if the columns are treated as only pinned at the top. There is no advantage in rigid connections at the tops of the columns, except in the increased resistance which such connections offer to vibration and shocks due to machinery, moving loads, etc. The design for wind pressure does not take these into account. In fact, there is a distinct point of economy in the reduced stresses caused by designing for "pinned" ends at the tops of the columns.

Case B—3 is rarely applicable, as it is seldom that one would be led to design the top end of the column with special resistance to bending moment, and leave the base free to deflect. The concentration of resistance to rotation at the tops of the columns increases the stresses very considerably throughout almost the entire structure, causes considerable alternations of stress from tension to compression in certain members, according as the wind blows or not, and creates excessive secondary stresses at the connections with the columns. Without the greatest care in the design and construction of these top connections there would be enough yielding, while at the same time a large amount of the secondary stress would be maintained, to go far toward placing the structure under class B—4, and it would be better to design it under that class at the outset.

The C series of cases is not very usual in practice, largely because of the greater cost, and the difficulty of field erection when gusset plates are used. The gusset brace gives an admirably stiff connection to resist shock and vibration. Its solid appearance, however, and the greater cost usually prevents its being designed to extend as far down the column as the ordinary knee brace would be carried, and in so far as this is true the gusset plate is a weaker design.

If the foot of the column is not rigid the stresses in the truss members throughout are the same as in case B—4, in which knee braces are used and the columns are pinned at both ends. In case the foot of the column is fixed the stresses come next above those in Case B—2, than which latter only the A series of cases gives smaller stresses.

One practical caution to be drawn from the above discussion is that one should not calculate the stresses as if the columns were "pinned" at the top, and then proceed regardlessly to design a rigid top connection with a view only to resistance to vibrations. This course is allowable within limits such that the top end of the column can still yield moderately to lateral deflection. In this event it comes theoretically under the condition known as a pinned end. But if the top connection is made decidedly rigid the result is a large increase in the possible stresses in the truss above those for which the latter was designed.

INTERNAL STRESSES IN THE COLUMNS.

The internal stresses in the columns are sowewhat complicated, partly because of the usually eccentric connections with knee braces, but especially because of the uncertainty of stress in the fibres inherent in the nature of the column as such.

If the column is of short length ratio, so that it can be treated as if it would yield by direct crushing, the latter consideration is largely eliminated, but in mill construction the columns are frequently too long to be so treated.

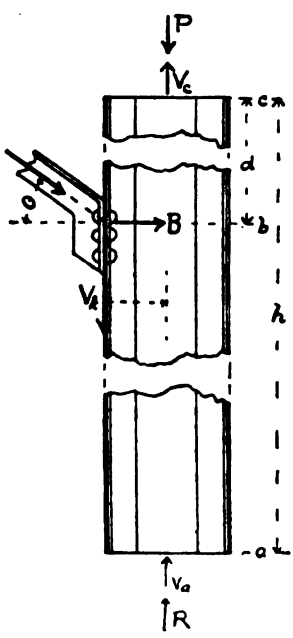


FIG. 6.—Forces acting on the column.

The dead load of the structure, as well as the effect of wind pressure, must be taken into account in determining the ultimate unit stresses.

Investigation gives the following analysis of the forces acting on, and the stresses existing in the column, due to the wind pressure and the dead load (see Fig. 6). The wind pressure causes a bending moment, M_x, at any section of the column, which is to be calculated by the proper one of the formulæ given for the various cases from A—1 to C—2 inclusive. The resulting unit stresses in the outer and inner flanges of the column due to the resistant moment can then be computed. The vertical component, V_k, of the stress in the knee brace is readily obtained, as the horizontal component B is known. It causes a bending moment, of which

the lever arm is half the width of the column, in case the knee brace is attached at the side. This bending moment may be taken as continuous in amount throughout the length of the column. The resulting unit stresses in the outer and inner flanges of the column due to the corresponding resistant moment can then be completed. V_k has, in addition, the effect of a vertical force of the value V_k distributed uniformly over the cross section of the column. V_a, which is computed by formulæ already given for each of the cases A—1 to C—2, is a direct tension or thrust uniformly distributed over the cross section of the column.

V_a and V_k are opposed to each other, and their resultant is the resistant of V_c. V_c is the vertical force that the truss exerts upon the top of column.

The weight of the roof, snow, machinery, or any other special loading causes a force, P, which is distributed over the cross section. The force P, together with the weight of the side of the building and of the column itself, is balanced by the reaction, R, at the footing.

If, as has been mentioned, the length of the column is small in proportion to the radius of gyration, so that it would yield by direct crushing rather than by bending, all these various effects just specified can readily be combined, and the ultimate unit stresses in the fibres at various sections of the column can be computed with a fair claim to definiteness. In case the column is of long length ratio it is best to design it for two conditions, namely: 1st, as a simple column of the full length without any knee brace, and loaded only with the force P applied at the top; 2d, as if it were a column of short length ratio with the knee brace attached, and to be treated as described for that kind of column.*

THE TRUSS PROPER (DETAILED).

The method has been given for finding, in all possible cases that

* This latter assumption is not strictly correct, but is as nearly so as is practicable. When the column formula has been rationalized further toward its perfect form, and more certainty of knowledge is possible concerning the maximum unit stress in the column, greater definiteness may be possible. In fact it is to a certain degree already attainable by the use of Professor Merriman's formula. In the present stage of discussion of the "column formula" however, this particular application of Merriman's formula to "mill construction" is largely in the nature of a theoretical refinement. It is not to be considered as a necessity of good design.

may arise, the values of the horizontal components, A, B, and C, of the forces acting on the columns, and also the vertical reactions, V_{c1} and V_{c2} at the bases of the columns.

A triangle of forces or simple equation, gives the stress in the knee brace. Thus (see figs. 3 and 6), for the leeward column, $K_2 = B$ sec. θ and vert. comp. of $K_2 = B$ tang. θ; also, for the windward column, $K_1 = (B - W_2)$ sec. θ, and vert. comp. of $K_1 = (B - W_2)$ tang. θ.

The resultant of V_c and the vertical component of K equals V_c, hence V_c can be found, (see page 239).

Having found the values of C, V_c, and K, and remembering that the same forces, but in the opposite direction, are the forces acting on the truss proper, all the external forces acting upon the truss are known. (See fig. 5). An ordinary diagram of stresses can now be constructed and the internal stresses of the truss determined. This is so simple and well-known a process as not to require a description. An example will now be given in detail, and the treatment of the truss will be involved in that.

Application to a Particular Example.

A bent from the main building of the plant at Niagara Falls belonging to the Pittsburg Reduction Company has been selected to illustrate the process (see Fig. 7). The table on page —— gives the wind load, the dead load, and the resultant stresses for this building under each of the nine cases from A—1 to C—2 inclusive. The corresponding diagrams are omitted however, except for Case B—1, which will serve as well as any of the others to illustrate the process. This case assumes that the columns are "fixed" at both ends.*

The members of the truss marked S are manifestly not strained either by the weight of the structure or by the wind load. They are in the structure to support machinery, overhead tracks, etc. It is a simple theoretical matter to take account of them, but as it would needlessly confuse the main issue they are omitted in this discussion.

* It has already been explained that in nearly all cases it is proper to assume that the columns are "pinned" at the ends. The general method of treatment is entirely similar. The assumption of fixed ends has been selected as a more comprehensive illustration of the process.

Data.

It is assumed that the weight of the structure above the tops of the columns is 12 pounds per square foot of horizontal projection; that the maximum snow load is 15 pounds on the same area, and that the maximum wind pressure is a horizontal force of 30 pounds per square foot of vertical projection.

The span is 85 ft. 0 ins. between centres of columns.

The bents are spaced 17 ft. 7½ ins. between centres of columns.

The columns are 26 ft. 0 in., long overall, from base to bearing of truss at top.

The distance from top of column to connection of knee brace is 10 ft. 7¼ in.

The total height from base of column to ridge of lantern is 61 ft. 6 in.

The rise of truss from bearing to apex of main rafters is 28 ft. 6 in.

The angle of knee brace is 45 degrees, hence the secant = 1.414 and the tangent = unity.

Calculations (see Case B—1, p. 245).

The total wind pressure upon the entire elevation of one bay equals 32580 lbs.

The wind concentration at foot of windward column, denoted by by W_1,=4080 lbs. That at the foot of windward knee brace, denoted by W_2,=6890 lbs.

$A_1=A_2=\frac{1}{2}(32580-4080)=14250$ lbs. (See p. 239).

$C=\frac{1}{2}A\frac{(h-d)^2}{d(\frac{2}{3}h-\frac{1}{2}d)}$.

$h=26.0$ ft. $d=10.6$ ft. $h-d=15.4$ ft.

$C=\frac{1}{2}\times 14250\times 1.86=13250$ lbs.

$B=A+C=27500$ lbs.

$M_{base}=h(B-C)-d(B-\frac{1}{3}C)=26\times 14250-10.6\times 23080=125850$ ft. lbs.

$M_{top}=\frac{1}{3}Cd=\frac{1}{3}\times 13250\times 10.6=46820$ ft. lbs.

$M_b=\frac{2}{3}Cd=\frac{2}{3}\times 13250\times 10.6=93640$ ft. lbs.

$V_{a1}=V_{a2}=\frac{1}{s}[\Sigma W\frac{1}{2}l-2M_{base}+2M_{top}]$.

$\Sigma W\frac{1}{2}l=$ total wind load $\times\frac{1}{2}$ total height$=32580\times\frac{1}{2}\times 61.5=1001835$ ft. lbs.

$\frac{1}{s} = \frac{1}{85} = 0.0118.$

$V_{a1} = V_{a2} = 0.0118[1001835 - 251700 + 93640] = 9960$ lbs.

$K_2 = B_2 \sec. 45° = 27500 \times 1.414 = 38890$ lbs.

$V_{k2} = B_2 \tan. 45° = 27500 \times 1 = 27500$ lbs.

$K_1 = (B_1 - W_2) \sec. 45° = (27500 - 6890)\ 1.414 = 29140$ lbs.

$V_{k1} = (B_1 - W_2) \tan. 45° = 20610 \times 1 = 20610$ lbs.

$V_{c2} = V_{k2} - V_{a2} = 27500 - 9960 = 17540$ lbs.

$V_{c1} = V_{k1} - V_{a1} = 20610 - 9960 = 10650$ lbs.

Construction of Force Polygons.

Very little comment is necessary upon the simple and well-known methods of graphical statics used in constructing the diagrams.

The external forces acting upon the truss are the external load concentrations, either dead load or wind pressure, as the case may be, the action of the knee braces at their points of connection, the horizontal reactions, C_1 and C_2, exerted by the tops of the columns, and the vertical reactions, V_{c1} and V_{c2}, likewise exerted by the tops of the columns.

The design of the truss is such that a stage is inevitably met in the course of building up the force polygon where one is confronted with more than two unknown forces to be dealt with. This requires that some one of several possible methods shall be used to meet the difficulty. The method here employed is to calculate by the equation of moments the stress in the lower chord of the truss. This stress being found, the obstacle is surmounted. There is a special advantage in calculating the stress in the lower chord of the truss by moments, in that it gives an admirable check upon the values of B, C, K, V_a, etc. By taking a section at the centre of the span and calculating the value of the stress in the lower chord, first for forces on the left of the section, and second for forces on the right of the section, it will be impossible to make the two results agree if there is any error in the previous work.

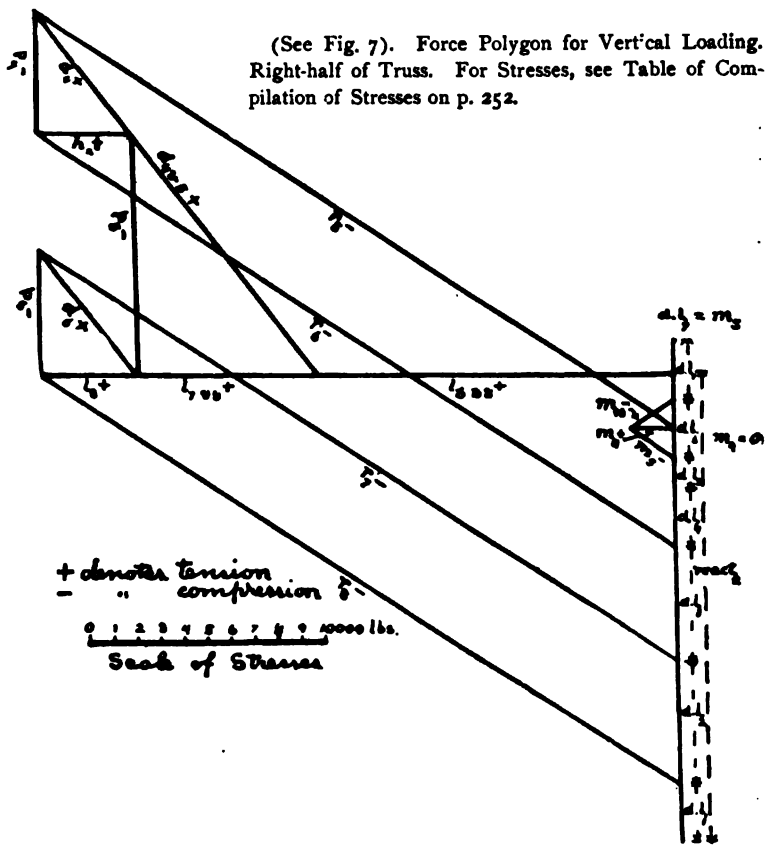
The method of bracing used in the truss causes the stress in the lower chord to be the same under all conditions, throughout the panels L_3, L_4, L_5, and L_6.

For the vertical loading the calculation of the stress in the lower chord is as follows: Taking a vertical section at the centre of the span, and the centre of moments at the apex of the main rafter, and using the forces on the left of the section, the equation is:

Zero= —L× 28½—load on one-half of span × ¼of span + reaction × ½ of span.

∴ L× 28½ =half total load × ¼span=20215 × 21.25.

∴ $L_{3\,to\,6}$=+15070 lbs. (+here denotes tension.)



(See Fig. 7). Force Polygon for Vertical Loading. Right-half of Truss. For Stresses, see Table of Compilation of Stresses on p. 252.

For the wind loading the calculation is the same in method, but more involved.

The section is taken vertically just to the right of the apex, and the centre of moments is taken at the apex of the main rafters. It is proper to remark in this connection that the stresses in the members of the lantern marked M_4, M_5, M_6, M_{10} and M_{11} will be

Panel lengths are all equal.

Bents are 17′–7½″ apart, c. to c. of columns.

Total height from foot of column to ridge of lantern — 61′–6″.

Rise of main rafter from top of column — 28′–6″.

Assumed loads as follows:

Weight of structure above columns — 12 lbs. per sq. ft. of hor. projection.

Weight of snow — 15 lbs. per sq. ft. of hor. projection.

Wind pressure — 30 lbs. horizontal force per sq. ft. of vert. projection.

No account is taken here of any special loads, such as machinery, overhead tracks, etc., supported from the lower chord.

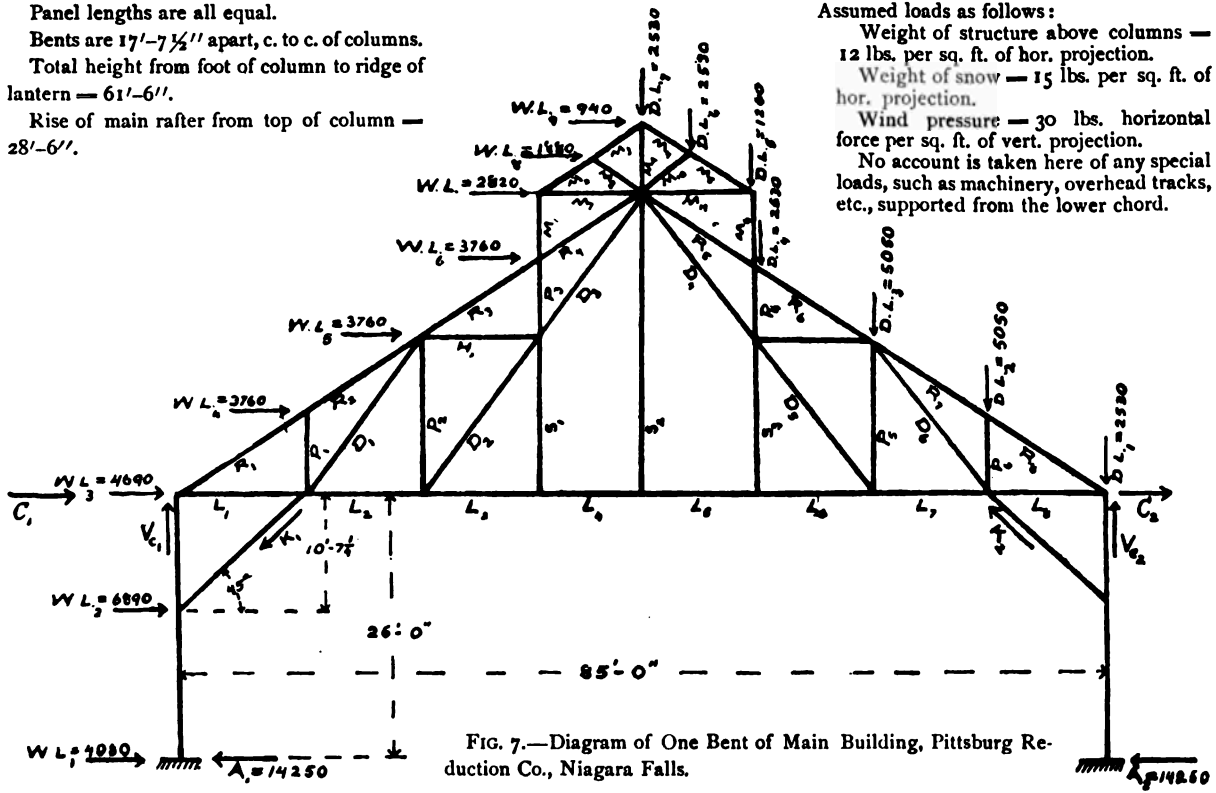


FIG. 7.—Diagram of One Bent of Main Building, Pittsburg Reduction Co., Niagara Falls.

(See Fig. 7). Force Polygon for Wind Loading, Case B—1. For Stresses, see Table of Compilation of Stresses on p. 252.

zero, for the wind acting on the left. The moments of the wind concentrations about the centre of moments are as follows:

Wind Load.	Amount in Pounds.	Lever arm in feet.	Moment in foot pounds.
W_3	4690	28.50	—133665
W_4	3760	21.38	— 80388
W_5	3760	14.26	— 53618
W_6	3760	7.10	— 26696
		Total—	—294367
W_7	2820	0.00	
W_8	1880	3.50	+ 6580
W_9	940	7.10	+ 6670
		Total—	+ 13250

The resultant moment of the wind concentrations about the centre of moments is—281100 foot pounds.

For forces on the left of the section the equation is, bearing in mind that the reactions exerted *by* the columns and knee braces are the reverses of the forces acting *upon* them,

$$\text{Zero} = -L \times 28.5 - C_1 \times 28.5 + V_{c1} \times 42.5 - K_1 \times 2.35 - 281100.$$

$$\therefore L \times 28.5 = -13250 \times 28.5 + 10650 \times 42.5 - 29140 \times 2.35 - 281100.$$

$$\therefore L_{3 \text{ to } 6} = -9800 \text{ lbs.}$$ (—here denotes compression.)

For forces on the right of the section the equation is,

$$\text{Zero} = L \times 28.5 - C_2 \times 28.5 \times V_{c2} \times 42.5 - K_2 \times 2.35.$$

$$\therefore L \times 28.5 = 13250 \times 28.5 - 17540 \times 42.5 + 38890 \times 2.35.$$

$$\therefore L_{3 \text{ to } 6} = -9700 \text{ lbs.}$$

The two results differ by about 1 per cent., and this is doubtless due to slight inaccuracies in the measurement of lever arms. This amount of discrepancy is unimportant and may be ignored.

It is unnecessary to explain in detail the construction of the two force polygons. The polygon for dead loading is constructed for one-half of the truss only. In both cases the polygon for external forces is first completed and then on that is built up the polygon of internal stresses. The compilation of the stresses for most of the members is given in the table on page 252, under Case B—1. The maximum stresses have been worked out for the wind acting upon the left side of the bent, but it will, of course, be understood that the conditions are reversed if the wind blows from the right.

LECTURE NOTES ON ROCKS.*

For Use Without the Microscope.

By J. F. KEMP.

Chapter VI. Remarks in Review of the Igneous Rocks.

Chemical Composition. Igneous magmas vary from about 80% silica as a maximum to practically none as a minimum, but important rocks rarely drop below 40%. Alumina is highest in the anorthosites or feldspathic gabbros, where it may exceed 25%. It is lowest in the pyroxenites and may be less than 1%. The oxides of iron are almost lacking in the highly siliceous, but may reach beyond 20% in the basaltic rocks, and with TiO_2 may be nearly 100% in some igneous iron ores. Lime attains its maximum of 12–15% in the gabbros and pyroxenites, while magnesia in the pyroxenites and peridotites may even surpass 25%. Potash is most abundant in the granites and leucite rocks; soda in those with nepheline. Combined alkalies may reach 15% in the phonolites and nepheline-syenites. In general they are, however, about 4–10, and may practically fail. Water in quantities over 1% as a rule is an indication of decay, but in the pitchstones this is not positively true, for the water reaches close to 10% and the rocks are apparently unaltered.

Texture. All three of the typical textures are easily recognized in characteristic development, but the glassy shade insensibly into the felsitic, the felsitic into the porphyritic, and the porphyritic into the granitoid. There are, therefore, intermediate forms that are difficult to classify. Yet, on the whole, the four textures are the most satisfactory basis for classification, and as a guide, in accordance with which to study. Chemical composition being the same, *texture is a result of the physical conditions surrounding the magma at the time of crystallization and of the presence of mineralizers.*

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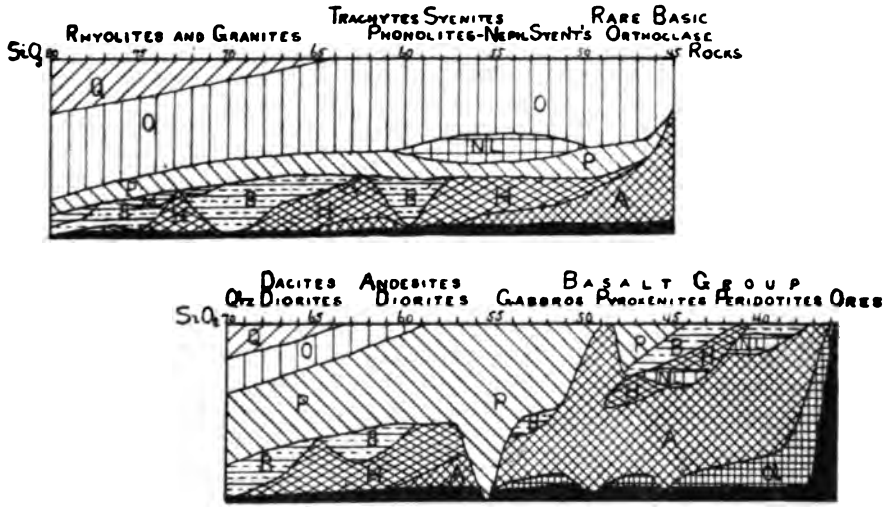
* Copyrighted by the author. Continued from p. 159 of the Quarterly for January, 1896.

Errata in January Number. P. 129, 12th line, porphyritic, not prophyritic; p. 142, the reference for analysis No. 7 should read, Weed and Pirsson; p. 143, 19th line, insert at end "Weed and."



Diagrams intended to illustrate graphically the mineralogical composition of the igneous rocks. The numbers indicate percentages in silica. The upper diagram includes the orthoclase rocks, the lower the plagioclase and non-feldspathic ones. Q is quartz; O, orthoclase; NL, nepheline and leucite; P, plagioclase; M, muscovite; B, biotite; H, hornblende: A, augite; Ol, olivine; the black area, magnetite, pyrrhotite, and other metallic minerals.

Mineralogy. The above diagrams, with a reasonable approximation to the truth, illustrate the quantitative mineralogy of the igneous rocks. A section cut through the charts at any one point expresses the relative amounts as well as kinds of the several minerals in the rocks whose names are along the top lines, and whose percentages in silica are approximately shown. No mention is made of texture. In the orthoclase rocks quartz disappears at about 65% SiO_2, while orthoclase continues to the end; plagioclase in small amount is quite constantly present throughout the series. Nepheline and leucite come in as indicated. Muscovite appears only in the more acidic granites. Biotite and hornblende vary in relative quantity, but toward the basic end both yield to augite. The rocks at the basic end are chiefly those recently discovered by Weed and Pirsson in Montana, by Iddings in the Yellowstone Park and by Lawson in the Rainy Lake region. In the plagioclase and non-feldspathic rocks quartz and orthoclase soon run out, so far as any notable or regular amount is concerned. Plagioclase holds along to about 45% SiO_2, and at about 55% SiO_2 may in the anorthosites be the only mineral present. Biotite and

hornblende are present all the way through, but toward the basic end they tend to yield in importance to augite, which latter in some pyroxenites, at about 49% SiO_2, may be the only silicate present. Olivine begins to appear at 55% and steadily increases with occasional lapses almost to the end, where it may be the chief mineral. The ores, as the last extreme, and without regard to silica, increase so as to be the only minerals in the rock, forming thus the theoretical basic extreme. The diagrams also emphasize the fact that igneous rocks shade into one another by imperceptible gradations, and this is true of the orthoclase and plagioclase groups themselves, although not suggested by the separation of the two in the drawings. The continuation of the orthoclase series to a basic extreme is a fact that we have only appreciated in very recent years.

A careful scrutiny of analyses and mineralogical composition leads to the conclusion that practically the same magma may, under different physical conditions of crystallization, afford mineralogical aggregates that vary considerably in the proportions of the several minerals—now yielding more hornblende, again more augite, and even affording quartz in a basalt. Hence, analyses in different groups overlap more or less, and the difficulty of drawing sharp lines of distinction is increased. Yet, allowing for this variation, chemical composition determines the resulting mineralogical aggregate and is fairly characteristic.

Determination of Igneous Rocks. In determining an igneous rock, the texture should first be regarded, next the feldspars. If orthoclase prevails, the presence or absence of quartz establishes the rock. If plagioclase prevails, we look for biotite, hornblende, pyroxene and olivine. If no feldspar is present we look for the presence or absence of olivine. On this basis the table on page 54 is to used—there are, however, many finely crystalline rocks which elude the power of the unassisted eye. If of light shades, they can generally be referred with reasonable correctness to the rhyolites, trachytes or felsites. If dark, the name "trap" is a very useful and sufficiently non-committal term. While books are of great assistance, really the only way to become properly familiar with rocks, is to use the books in connection with correctly labeled and sufficiently complete study collections.

Field Observations. A rock is not to be considered by any intelligent observer as a dead inert mass in nature, but as an important

participant in the ceaseless round of changes that confront us on every side. Familiarity with specimens and varieties in collections ought always to be followed by observation in the field. We have all grown to believe that in limited areas igneous rocks, however, varied, they may be, are yet intimately related in their origin, or are bound together by ties of kinship, "consanguinity" as Iddings has called it. Some regions like eastern Montana and the Black Hills have especial richness of high soda or potash magmas, giving rise to nepheline and leucite rocks, and sodalite syenites; Colorado, Utah and New Mexico have wonderful and enormous laccolites of andesities (porphyrites). The Pacific coast in South America has andesites in vast extent from active volcanoes, and in North America from extinct cones. Idaho, Oregon and Washington are marked by basalts. The Atlantic coast region has a long series of very ancient volcanoes, that preceded the early fossiliferous strata from Newfoundland to North Carolina and that yielded nearly the entire series of the volcanic rocks. In the Adirondacks, on the Hudson near Peekskill, near Baltimore and around Lake Superior we find the members of the gabbro family; while near tidewater along the Atlantic seaboard we have granites, almost all with biotite. These facts have suggested the creation of the term "petrographic provinces," by J. W. Judd, in the endeavor to suggest these kinships of magmas in certain limited districts. There are many others even in North America that could be cited, but the above will suffice to remind the reader that these broader relationships should be always before him while extending his acquaintance with rocks as they occur in the natural world about him.

CHAPTER VII. THE AQUEOUS AND EOLIAN* ROCKS. INTRODUCTION. THE BRECCIAS AND MECHANICAL SEDIMENTS NOT LIMESTONES.

The members of this, the second grand division, are much simpler, and, as a general thing, much easier to identify and to understand than are the igneous. No single term is comprehensive enough to include them all, and even the double one selected above, in the endeavor to embrace as many as possible, and to avoid the multiplication of grand divisions, still falls short of including several. Nevertheless, those not embraced (the breccias) are of limited distribution, and, for many reasons, go best with the other fragmental

*Although Aqueous was used alone on an earlier page (48), Eolian should have been added for completeness, and is here introduced.

rocks, even if, strictly speaking, they are neither aqueous nor eolian in origin. Sedimentary is a most useful term, and is universally applied as a partial synonym of the above, for it fairly includes the most important members of the series, but the rocks deposited from solution and the eolian rocks can hardly be understood by it.

The rocks will be taken up under the following groups:

I. Breccias and Mechanical Sediments, not Limestones.
II. Limestones.
III. Organic Remains, not Limestones.
IV. Precipitates from Solution.

The limestones are reserved for a special group, although they belong in instances to each of the other three. They form, however, such an important series in their scientific and practical relations, that it is in many respects advantageous to take them all up together.

I. Breccias and Mechanical Sediments, Not Limestones.

Group I. is described in order from coarse to fine in the following series, minor varieties not cited in the table being mentioned in the text under their nearest relatives.

Coarse			to		Fine.
Breccia.	Gravel and Conglomerate.	Sand and Sandstone.	Argillaceous Sandstone.	Silt and Shale.	Clay.
			Calcareous Sandstone.	Calcareous Shale.	Marl.

BRECCIAS.

The word breccia is of Italian origin and is used to describe aggregates of *angular* fragments cemented together into a coherent mass. The breccias cannot all be properly considered to be either aqueous or eolian, and some have already been referred to under the fragmental igneous rocks. Oftentimes they resemble conglomerates, but, unless formed of fragments of some soluble rock, whose edges have become rounded by solution, there is no difficulty in distinguishing them. Breccias, as regards their angular fragments and interstitial filling, may be of the same materials or

of different ones. We may distinguish *Friction breccias* (Fault breccias), *Talus breccias*, and, for the sake of completeness, may also mention here *Eruptive breccias*.

Friction breccias are caused during earth-movements by the rubbing of the walls of a fault on each other, and by the consequent crushing of the rock. The crushed material of finest grade fills in the interstices between the coarser angular fragments, and all the aggregate is soon cemented together by circulating mineral waters. Such breccias occur in all rocks and are a frequent source of ores which are introduced into the interstices by infiltrating solutions. Quartz and calcite are the commonest cements.

Talus breccias are formed by the angular debris that falls at the foot of cliffs and that becomes cemented together by circulating waters, chiefly those charged with lime.

Eruptive breccias may be produced either by the consolidation of coarse and fine fragmental ejectments like tuffs, or by an erupting sheet or dike that gathers in from the wall rock sufficient fragments as inclusions to make up the greater part of its substance. These are finally cemented together by the igneous rock itself and afford curious and interesting aggregates, oftentimes representing all the rocks through which the dike has forced its way to the surface. A crust may also chill on a lava stream, and when an added impulse starts anew the flowing, the crust may be shattered into an eruptive breccia of a still different type.

We often speak of breccias as "brecciated limestone," "brecciated gneiss," or some other rock, making thus the character of the original prominent. When the fragments and the cement are contrasted in color, very beautiful ornamental stones result, which may be susceptible of a high polish.

A moment's consideration of the above methods of origin will convince the reader that breccias, except as formed of loose volcanic ejectments are of very limited occurrence. Although deeply buried rocks that share in profound earth movements often suffer crushing and brecciation on a large scale, the effects are chiefly detected by microscopical study.

Generalities Regarding Sedimentation.

In the production of the rocks next taken up, moving water plays so prominent a part that its general laws are described by way of necessary introduction. All streams or currents

charged with suspended materials exercise a sorting action during the deposition of their loads. With materials of the same density the sorting will grade the deposit according to the sizes of the particles. With materials of different densities, smaller particles of heavier substances will be mixed with larger particles of lighter ones. Assuming a swift current, it readily appears that, when it slows up, the large and heavy fragments drop first of all; then the smaller fragments of the heavier materials and the larger ones of those successively lighter, until at last the smallest particles of the lightest rock alone remain in suspension. It is also important to bear in mind that, the density being the same, the size of the transportable particle increases with the sixth power of the velocity. Thus, if we have a current of the proper velocity it will be able to lift a grain of quartz a sixteenth of an inch in diameter; but if the velocity is doubled, the transportable particle will be four inches in diameter. An appreciation of this law makes the size of boulders moved by many streams, in times of flood, less surprising. On the other hand, when the suspended material becomes excessively fine, the ratio of its surface to its volume is so extremely high that adhesion, or chemical action akin to hydration, or some other influence not well understood, operates in pure, fresh waters, so as to practically render sedimentation impossible, even if the medium is perfectly quiet. W. M. Brewer has shown by a series of experiments with all sorts of clays, lasting over many years, that if we introduce into such an emulsion a mineral acid or a solution of salt, or of some alkali, the turbidity clears with remarkable quickness. When, therefore, sediment-laden streams flow into the ocean, or into salt lakes, even the finest part of their load speedily settles out.

While we may state thus simply the laws of sedimentation, we must not expect in Nature such well-sorted and differentiated results as would at first thought appear to be the rule. Of rivers and shore currents—the two great transporting agents—the former are subject to floods and freshets, giving enormously increased efficiency for limited periods, and again to droughts, with the same at a minimum. Hence varying sediments overlap and are involved together. Eddies and quiet portions in the streams themselves contribute further confusion, and an intermingling of coarse and fine materials. Shore currents have parallel increases of violence in times of high wind and storms, and sink again in times of calm.

Eolian deposits are subject to even greater fluctuation, and their irregularities are more pronounced than those of the true Aqueous. Both these classes of rocks are marked by a more or less perfect arrangement of their materials in layers. The layers give rise to regular beds, in deposits from quiet and uniform currents, and, although in those from swift ones they are very irregular, as explained above, nevertheless *bedding*, or *stratification*, is in the highest degree characteristic of the Aqueous and Eolian grand division.

When in the presence of these sedimentary rocks in the field, the observer should always appreciate that they reproduce past conditions, and that they indicate the former presence of water, either in a state of agitation and with high transporting power for the coarse varieties, or as quiet reaches in which were laid down the finer deposits. Rightly appreciating and interpreting them, we may see that the ocean has advanced across the land in times of submergence, leaving behind its widening trail of shore gravels, now conglomerates; that these have been followed up and buried first by fine offshore sediments, and later by the remains of organisms now appearing as limestones, until succeeding elevation causes the waters again to retreat and prepare the way for another "cycle of deposition."

Gravels and Conglomerates.

Loose aggregates of rounded and water-worn pebbles and boulders are called gravels, and when they become cemented together into coherent rocks they form conglomerates. Sand almost always fills the interstices. Silica, calcite and limonite are the commonest cement. The component pebbles are of all sorts of rock depending on the ledges that have supplied them, hard rocks of course predominating. Rounded fragments of vein quartz are especially frequent. Gravels and conglomerates, if of limited extent, indicate the former presence of swift streams; if of wide area they suggest the former existence of sea beaches and the advance of the sea over the land. Component pebbles are of course older than the conglomerate itself, and if igneous, they may establish the age of the intrusion as older than the conglomerate. Fossiliferous boulders prove the age of the conglomerate as later than their parent strata. Under favorable circumstances gravels may be cemented to conglomerates in a comparatively few years. Conglomerates are exclusively aqueous. Gravels and conglomerates

graduate by imperceptible stages into pebbly sands and sandstones, and these into typical sands and sandstones. Notably unsorted aggregates of relatively large and more or less angular boulders in fine sands or clay indicate glacial action.

Metamorphism. Under dynamic stresses, especially in the nature of pressure and shearing, the pebbles of a conglomerate may be flattened and rolled out into lenses, and such are often observed. If the pebbles are feldspathic as is the case in those from granite ledges, and if the interstitial filling is aluminous and not purely quartzose as in the commonest cases, conglomerates, when recrystallized, may pass into augen-gneisses with their characteristic "augen," or "eyes" of feldspar and quartz that but faintly suggest their original character. Excessive metamorphism may further develop types closely simulating granite, forming thus the so-called "recomposed granite" of the Lake Superior regions

Occurrence. Gravels are too familiar to require further reference. Conglomerates are met in all extended sedimentary series. Our greatest one lies at the base of the productive Coal Measures o Pennsylvania and adjacent States. It is properly called the "Great Conglomerate." Remarkable ones with squeezed pebbles are met in the Marquette iron region of Michigan. In Central Massachusetts there is an augen-gneiss, that has been derived from a Cambrian conglomerate. It is quarried at Munson, and sold as granite, and is a widely known building stone. Around Narragansett Bay, R. I., are conglomerates, in part at least of Carboniferous age, in all stages in the progress to gneiss.

SANDS AND SANDSTONES.

	SiO_2.	Al_2O_3.	FeO Fe_2O_3.	MnO.	CaO.	MgO.	K_2O.	Na_2O.	Loss.	Sp. Gr.
1.	99.78	0.22	. .	. .	. .	. .	. .	. .	. .	
2.	98.84	0.17	0.34	tr.	tr.	tr.	. .	. .	0.23	
3.	99.62	. .	0.13	0.7	. .	. .	. .	. .	. .	
4.	99.47	0.17	0.12	. .	0.90	0.50	0.07	0.15	0.12	2.648
5.	95.85	2.64		. .	0.81	0.08	. .	. .	0.45	(2.245)
6.	94.73	0.36	2.64	. .	0.38	0.36	. .	. .	0.83	
7.	91.67	6.92	tr.	. .	0.28	0.34	. .	. .	1.17	2.240
8.	82.52	7.07	3.55	1.42	1.83	tr.	tr.	tr.	3.61	
9.	69.94	13.15	2.48	0.70	3.09	tr.	3.30	5.43	1.01	(2.36)

1. Sand from Cambrian Quartzite, Chesire, Mass., S. Dana Hayes, *Mineral Resources*, 1883–'84, p. 962. 2. Oriskany Sandstone, Juniata Valley, Penna. A. S. McCreath, *Idem*. 3. Siluro-Cambrian saccharoidal sandstone, Crystal City, Mo. Analyzed by Glass Co. 0.22 not determined, *Idem*. 4. Novaculite, Rockport, Ark. R.

N. Brackett, for L. S. Griswold, Geol. Ark., 1890, III. 161. 5. Salmon-red Triassic Sandstone, Glencoe, Colo. Quoted by G. P. Merrill, "Stones for Building and Decoration," p. 420. The Sp. Gr. is of one from Ralston, near by. 6. Cambrian red Sandstone, Portage Lake, Mich., *Idem.* 7. Light-gray sub-carboniferous sandstone, near Cleveland, Ohio, *Idem.* 8. Olive-green carboniferous sandstone, Dorchester, N. B., *Idem.* 9. Red triassic sandstone (brownstone, arkose), Portland, Conn., *Idem.*

Comments on the Analyses. The first three illustrate the purity of the sand in exceptional cases. We may properly infer that the sediments were derived either from preëxisting sandstones, that had already been once sorted and separated from their aluminous ingredients, or from excessively weathered and kaolinized quartzose rocks, such that the feldspar had entirely passed into clay, and had been eliminated in deposition. No. 4 is a novaculite, and is an excessively fine, fragmental deposit. Nos. 5, 6 and 9 are red sandstones, and indicate the comparatively small percentage of iron oxides that may cause a deep coloration. No. 6 is free from iron, but has some aluminous material, evidently a very pure clay, from the lack of iron. No. 7 has its iron as protoxide, for the rock is a green variety. Its manganese oxide is worthy of remark. No. 8 is a feldspathic sandstone, or arkose, whose analysis, except that the Al_2O_3 is low and the CaO rather high, might answer for a granite.

The specific gravity of sandstones varies widely. Quartz itself is 2.6–2.66, and specially dense sandstones reach 2.5, but, being characteristically porous rocks, the usual range is 2.2–2.4. They often go lower and may even reach 1.8.

Mineralogical Composition, Varieties. The mechanical sediments whose predominant particles are finer than pebbles, and yet, in most cases, of notable size, are grouped under this head. They are found in all stages of coherence, from loose sands to excessively hard metamorphic rocks called quartzites. Quartz is much the commonest mineral that contributes the grains, as it is the most resistant of the common rock-making minerals. In river sands the grains are angular, but in those continually swashed together on a sea beach, they become more or less rounded. Garnets, magnetite, zircon and other hard and resistant minerals are widely distributed in small quantities. Feldspathic sands also occur, and when they are compacted to firm rock they are called arkose. As in the conglomerates, the cementing materials of sandstones are silica, calcite and limonite, but in many the character or cause of the bond is rather obscure. Those with siliceous cement yield the most

durable stone for structural purposes; those with ferruginous afford the greatest range of colors, such as olive-green, yellow, brown and red. Calcareous cements may be detected by their feeble effervescence. Sandstones entirely formed of calcareous fragments are known, but are described under limestone.

A curious and exceptional rock is novaculite, that is extensively developed in Arkansas. It was long thought to be allied to the cherts, which it much resembles, but microscopic investigation has led Griswold to determine it to be a finely fragmental deposit of quartz grains, practically a siliceous ooze. In fineness it is parallel with the clays, but it contains little else than silica.

Aqueous sandstones generally exhibit well-marked bedding planes, although cases are familiar in which the bedding is excessively coarse and the layers are extremely thick. Swirling eddies in the original stream or currents give rise to cross-bedding and various irregularities. In fact, all the phenomena of beaches and stream-bottoms, such as ripple-marks, worm-borings, shells, etc., are preserved in sandstones.

Eolian sands are usually of aqueous deposition in their original condition, but they are afterwards taken up by the wind and driven along as dunes and dust into more or less remote districts. When they finally reach a state of rest and consolidate they have very irregular stratification, cross-bedding, swirling curves, pinching and swelling layers and other characteristic phenomena. Finer varieties afford a surface deposit that is generally called "loess," and that may lack all stratification. More or less water-transported material is also intermingled, making the term one of not particularly sharp definition. This mixed character has made the loess of many localities a rather puzzling geological problem. It is always loosely textured and is important in its relations to agriculture.

Sands and sandstones pass by insensible gradations into the varieties in the upper line of the series shown in the tabulation on p. 271 by the increasing admixture of clayey or argillaceous materials. The base is kaolin, Al_2O_3, $2\,SiO_2$, $2\,H_2O$, a mineral that forms microscopic, scaly crystals and that has the property of plasticity, and this property it lends to the last members of the series, which in exceptional cases may contain little else. The lower series passes gradually into the fragmental limestones, by the increasing admixture of calcite.

Metamorphism. The purer sandstones in metamorphism yield

quartzites which are denser and harder than their originals, because by deposition of cementing quartz, the fragmental grains are very firmly bound together. The later deposited quartz often conforms to the optical and crystallographic properties of the grain around which it crystallizes. No sharp line divides sandstones and quartzites; they shade imperceptibly into one another. Less pure sandstones, if crushed and sheared in the metamorphic process, yield siliceous or quartz schists from the development of micaceous scales between the grains. Flexible sandstone or itacolumite, appears to owe to them its property of bending.

Occurrence. Sandstones are so common in all extended geological sections as to deserve no special mention. They are the most widely used of building stones.

ARGILLACEOUS SANDSTONE, SHALE, CLAY.

	(a) SiO_2	(b) SiO_2	Al_2O_3	FeO Fe_2O_3	CaO	MgO	K_2O	Na_2O	(a) H_2O	(b) H_2O
1.	63.31		16.16	3.79	0.15	4.44	7.56	1.54	2.65	
Shale.										
2.	69.92		23.46	0.20	0.48	0.40	1.43		3.84	
3.	67.29		15.85	6.16	0.95	0.19	8.71		. .	
4.	64.37		19.73	9.07	0.82	2.32	3.78		. .	
5.	62.86		20.65	9.21	0.48	0.34	. . .		6.26	
6.	58.45		21.96	8.43	1.05	1.57	4.00		6.51	
7.	43.13		40.87	3.44	8.90	5.32	2.42		0.20	
Brick Clay.										
8.	81.71		9.81	3.80	0.48	0.26	. .		3.91	
9.	75.88		11.22	5.04	0.48	0.35	. .		6.76	
10.	65.14		13.38	7.65	2.18	2.36	8.51		. .	
11.	62.00		18.10	9.11	. .	. .	. .		5.66	
12.	57.80		22.60		4.85	2.07	. .		12.68	
13.	53.77		20.49	9.23	2.04	4.22	9.60			
14.	45.73		29.69	6.86	0.44	1.01	3.42		12.86	
Potters' Clay.										
15.	27.68	36.58	22.95	1.28	0.45	0.37	1.96		6.74	2.05
16.	42.28	18.02	24.12	1.46	0.59	0.68	2.42		7.77	0.86
Fire Clay.										
17.	61.60		28.38	0.52	0 46	0.36	. .		5.08	
18.	38.10	12.70	31.53	0.92	.	tr	0.40		11.30	2.50
19.	45.29		40.07	1.07	0.26	0.08	0.48		13.18	
Residual Clay.										
20.	55.42		22.17	8.30	0.15	1.45	2.49		9.86	
21.	33.55		30.18	1.98	3.89	0.26	1.57		10.72	
22.	46.50		39.57	. .	. .	. .	. .		13.93	

NOTE. Where two values of SiO_2 are given, the first is the combined silica, *i. e.*, chiefly in kaolin, and the second the free silica, which is practically comminuted quartz.

Under H_2O, where two values are given, the first is combined water, likewise chiefly in kaolin, the second is the free water, which has simply soaked in.

1. Argillaceous sandstone, Chickies Station, Penn. R. R., Geol. Surv. Penn. Rep. M, 91. 2. Haydensville, Hocking Co., O. Quoted by H. Ries, *XVI. Ann. Rep. Director U. S. Geol. Survey, Part IV.*, p. 572. 3. Hornellsville, Steuben Co., N. Y., *Ibid.* 572. 4. Kansas City, Mo., *Ibid.* 570. 5. Red Shale, Sharon, Mercer Co., Pa., *Ibid.* 572. 6. Leavenworth, Kan., *Ibid.* 570. 7. Clinton, Vermilion Co., Ind., *Ibid.* 570. 8. Washington, Daviess Co., Ind., *Idem.* 566. 9. Salem, Washington Co., Ind. *Idem.* 566. 10. Red Clay, Plattsburg, Clinton Co., N. Y., *Ibid.* 568. 11. Red Clay, Lasalle, Ill., *Ibid.* 564 12. Rondont, N. Y., *Ibid.* 568. 13. Brown Clay, Fisher's Is., N. Y., *Ibid.* 568. 14. Hooversville, Somerset Co., Pa., *Ibid.* 568. 15. Akron, O., *Ibid.* 562. 16. East Liverpool, O., *Ibid.* 562, also TiO_2, 1.20. 17. Woodbridge, N. J., *Ibid* 556. 18. Cheltenham, Mo., *Ibid.* 556. 19. Woodland, Pa., *Ibid.* 556. 20. Morrisville, Calhoun Co., Ala., *Ibid.* 574. 21. Near Batesville, Ark., *Ibid.* 574, also P_2O_5, 2.53. 22. Pure Kaolin—$Al_2O_3\ 2SiO_2,\ 2H_2O$.

Comments on the Analyses. The analyses are significant when compared with those of the sandstones on p. 275. It at once appears that there is a great decrease in silica, and a great increase in alumina, and, as a rule, in all the other bases and water. Among themselves there is wide variation, but by using No. 22, as indicating pure kaolin, it is possible to infer how much quartz sand is mingled with the clay, due allowance being made for the fragments of unaltered feldspar, as shown by the alkalies, for silicates, hydrous and anhydrous, involving iron, lime and magnesia, and for carbonates of lime, magnesia and iron. Shales and brick clays are shown to be comparatively impure admixtures of kaolin and quartz; potter's clay is much less so, and fire clay is little else than these two. No. 19 is practically pure kaolin.

Mineralogical Composition. Varieties. The argillaceous sandstones have a finer grain than the sandstones proper, and tend to form thin but tough beds. They find their best examples in the flagstones of our eastern cities. Shales lack this coherence and break readily into irregular slabs and wedge-shaped fragments of no notable size. As sands give rise to sandstones, so on hardening and drying, muds and silt yield shales. Shales show all grades from gritty and coarse varieties to fine and even ones approximating clays. The finer shales when ground have the same plasticity as clay, and are often moulded and baked into brick, especially of the vitrified kinds for paving. Shales may be black from bituminous matter in them, and are then described as "bituminous." They grade into cannel coals, but great areas of them such as the Genesee Shale of New York and the Huron Shale of Ohio, have as much

as 8 to 20% hydrocarbons and yield quite copious products on distillation.

As the particles of quartz present become finer and finer and not too abundant, the plasticity of the kaolin present asserts itself so that the shales pass into clays. In the most even and homogeneous grades, they show but slight grit to the teeth, but in coarser varieties they are decidedly gritty even to the fingers. They are often separated into thin beds by layers of sand that mark the times of freshets and deposition of coarse material during their formation. Clays of earlier geological date are hard and dense rock and must be ground before use. Such are the fire-clays immediately beneath Carboniferous coal-seams. Clays are blue, red and brown according to the state of the iron oxide, whether ferrous or ferric, or they may be nearly white when it fails. The less pure brick clays as shown by the analyses contain oxides of iron, calcium, magnesium, and of the alkalies in quantity, but fire-clays practically lack these.

As contrasted with the transported or sedimentary clays just mentioned, there are residual clays that result from the decay of impure limestones and that are found on their weathered outcrops. They are very impure and variable in composition, but they are markedly plastic.

Metamorphism. In metamorphic processes shales become compacted and oftentimes silicified. Their lack of homogeneity causes them to yield irregularly breaking and very tough rocks called graywackes, which differ only in greater hardness from their unaltered originals. Excessively silicified shales are called phthanites and are important in the Coast Range of California. Shales also under shearing stresses and attendant mineralogical reorganization pass into schists of various kinds, such as quartz-schist, mica-schist and possibly hornblende-schist. G. F. Becker even mentions rocks derived from them that are mineralogically like diabases and diorites, but their recognition is a matter for microscopic study. Clays under shearing stresses develop new cleavages without regard to their original bedding and from the homogeneous character of the original and the perfection of the cleavage, slates result, which are of great practical importance.

Occurrence. Shales and clays are such common members of extended geological sections as to deserve no special mention. They are often a thousand feet or more in thickness and cover great areas.

CALCAREOUS SANDSTONES, MARLS.

	Calc. Sandst.	SiO_2	Al_2O_3	FeO Fe_2O_3	CaO	MgO	K_2O	Na_2O	CO_2	H_2O or Loss
1.		79.19	3.75		7 76	3.20	. .	.		3.26
2.		38.41	5.77	1.79	20.08	8.82	0.12	0.29		
Calc. Shales.										
3.		39.70	26.83		19.28	2.43	5.11			
4.		28.35	12.37		21.47	8.24	5.73			
Marls.										
5.		43.70	25.00		8.85	2.33	. .	. .	5.40	9.21
6.		38.70	10.20	18.63	9.07	1.50	3.65	. .	6.14	10.00
7.		28.78	11.63	2.96	24.50	2.91	2.12	. .	22.66	4.18

1. Calcareous sandstone, Flagstaff, Ariz. Quoted by G. P. Merrill, *Stones for Building and Decoration*, 420. 2. Calcareous sandstone, Jordan, Minn., *Idem.* 3. Genesee Shale, Mt. Morris, N, Y., supplied by H. Ries. 4. Niagara Shale, Rochester, N. Y., H. Vulté, analyst. Supplied by H. Ries. 5. Cretaceous Marl, Hop Brook, N. J. *Geol. of N. J.*, 1868, 419; also P_2O_5, 2.18. 6. Cretaceous Marl, Red Bank, N. J., *Idem*, 418; also P_2O_5, 1.14, SO_3 0.14. 7. Subcarboniferous marl, Bowling Green, Ky. *Ky. Geol. Surv.*, Chem. Analyses A, Part 3, 90; also, P_2O_5, 0.25.

Comments on the Analyses. The analyses illustrate in a very suggestive way the passage of these mechanical sediments into impure limestones. The gradual intermingling of more and more of shells and other remains of organisms brings it about. The high P_2O_5 of the marls, as cited under the references, is worthy of remark. It is to be appreciated that the lime and magnesia and some of the iron of the analyses are to be combined with CO_2, even though the CO_2 is not mentioned.

Mineralogical Composition. Varieties. Calcareous sandstones are practically sandstones with rich calcareous cement, or with a large amount of organic fragments intermingled with the prevailing quartz sand. They are passage forms to the fragmental limestones. Calcareous shales derive their lime partly from the fine organic sediment that is deposited with the siliceous and aluminous particles, and partly from contained fossils. Beds of these rocks are particularly favorable layers for the discovery of the latter, and often break the monotonous barrenness of a geological section composed of ordinary shales. Marls, strictly speaking, are calcareous clays, and originate in typical cases by the deposit of limy slimes along with the aluminous. The lime destroys the plasticity of the clay and yields a crumbling rock, often richly provided with fossils and of value as a fertilizer. Grains of glauconite, the green silicate of potash and iron, are at times present, and characterize the so-called "green sands" that are valuable as fertilizers. The term marl is

somewhat loosely used in its applications, and moderately coarse calcareous sands, and even beds that show but small percentages of lime on analysis are designated by it in the States along the Atlantic seaboard from New York south. It is clear that marls are intermediate rocks between clays and impure earthy limestones.

Metamorphism. The rocks of this group are altered in metamorphic processes to schistose forms, not so essentially different from those resulting from the common aluminous shales and clays, except that the richness in lime facilitates the production of minerals requiring it. The marls, when high in lime, behave like impure limestones, and are prolific sources of silicates. Marls are, however, much more common in later and unmetamorphosed formations than in older ones, although it may be that in the latter they have yielded some schistose derivatives not readily traced back to them.

Occurrence. Calcareous sandstones and shales are met as occasional beds in series of the more abundant, distinctively aluminous varieties. Marls are chiefly developed in the Cretaceous and Tertiary strata of the Atlantic seaboard and around the Gulf of Mexico. Freshwater ones are not lacking in the Tertiary lake basins of the West.

CHAPTER VIII. LIMESTONES; ORGANIC REMAINS, NOT LIMESTONES; ROCKS PRECIPITATED FROM SOLUTION. DETERMINATION OF THE AQUEOUS AND EOLIAN ROCKS.

II. LIMESTONES.

	SiO_2	Al_2O_3	FeO Fe_2O_3	CaO	MgO	CO_2	H_2O	Insol.	$CaCO_3$	$MgCO_3$
Living Organisms.										
1. (Coral)				54.57			2.54		97.46	
2. (Reef-rock)				53.82	1.01				96.11	2.13
3. (Lagoon Sed.)				54.58	.85				97.47	1.79
4. (Coral)				44.96	3.87				80.29	8.14
5. (Oyster Shells)				44.4	1.3	35.4	14.5		(79.28)	(2.73)
Calcite.										
6. Pure Mineral.				56.		44.			100.	
Dolomite.										
7. Pure Mineral.				30.43	21.72				54.35	45.65
Marine Limestones.										
8.	0.63		0.55	55.6	0.23				99.30	0.49
9.			1.06	53.78	0.34		0.90	1.13	96.04	0.72
10.			1.25	53.89	0.10				96.24	0.21
11.	1.84	0.64	1.82	51.40	2.23	41.19	0.27		91.80	4.68
12.	12.34		7.00	44.41	0.44				79.30	0.92
13.	3.77	0.08	6.80	33.79	15.32	42.21			60.35	32.61

	SiO_2	Al_2O_3	FeO Fe_2O_3	CaO	MgO	CO_2	H_2O	Insol.	$CaCO_3$	$MgCO_3$
14.			0.55	29.54	21.08		1.82	0.60	52.75	44.28
Waterlime.										
15.	18.34		7.49	37.60	1.48		3.94		67.14	2.90
16.	15.37		11.38	25.70	12.44		1.20		45.91	26.14
Siliceous.										
17.			1.20	17.69	10.59		1.24	43.72	31.60	22.24
Freshwater Limestone.										
18.			0.37	54.16	0.15	43.68		1.49	96.71	0.31
19.		1.83	0.22	34.20	0.11	26.79	4.64	31.28	61.07	0.23
Travertine.										
20.	0.08		0.15	53.83	0.90	41.79	1.43		94.97	0.43

1. Stag's horn coral, (*Millepora alcicornis*), S. P. Sharpless, *Amer. Jour. Sci.* Feb., 1871, 168. 2. Bermuda coral reef rock. A. G. Högbom, *Neues. Jahrb.*, 1894, I. 269. 3. Bermuda coarse lagoon sediment, *Idem.* 4. Average of 14 analyses of the coral *Lithothamnium* from localities the world over, *Idem*, 272. 5. Oyster shells, *Geol. of New Jersey*, 1868, 405. 6. Calculated from $CaCO_3$. 7. Calculated from $CaCO_3$, $MgCO_3$. 8. Crystalline Siluro-Camb. limestone, Adams, Mass., E. E. Olcott for Marble Co. 9. Limestone, Bedford limestone, Ind. Quoted by T. C. Hopkins, *Mineral Industry*, 1894, 505. 10. Solenhofen lithographic stone. Quoted by G. P. Merrill, *Stones for Building and Decoration*, 415. 11. Limestone, Hudson, N. Y., Th. Egleston. 12. Trenton Limestone, Point Pleasant, Ohio, vide No. 10. 13. Surface Rock, Bonne Terre, Mo., J. T. Monell, *unpublished.* 14. Limestone, Chicago, T. C. Hopkins, *Mineral Industry*, 1895, 508. 15. Hydraulic limestone, Coplay, Penn. Quoted by W. A. Smith, *Mineral Industry*, 1893, 49. 16. Hydraulic limestone, Rosendale, N. Y., *Idem.* 17. Siliceous limestone, Chicago, Ill., vide No. 14. 18. Miocene limestone, Chalk Bluffs, Wyo., R. W. Woodward, 40th Parallel Surv. I. 542. 19. Eocene limestone, Henry's Forks, Wyo., B. E. Brewster, *Idem.* 20. Travertine, below Hotel Terrace, Yellowstone Park, J. E. Whitfield, for W. H. Weed, *9th Ann. Rep. Dir. U. S. Geol. Surv.*, 646.

Comments on the Analyses. The first three and the fifth analyses indicate that the calcareous parts of living organisms are quite pure calcium carbonate. The fourth analysis is of that species of coral which, so far as we know, is highest in magnesia. Small amounts of calcium phosphate are often present as well, some shells being richer than others. Nos. 6 and 7 are introduced so as to give a basis for estimating the purity of the following limestones: Nos. 8, 9 and 10 are extremely pure varieties, and from these, as a starting point, the other components increase in one analysis and another. No. 14 is a nearly typical dolomite. Nos. 12 and 17 are highly siliceous, and Nos. 15 and 16 are both strongly argillaceous. The last two are closely parallel in composition with marine varieties. An analysis of a travertine is given in No. 20.

It at once appears that Nos. 13, 14, 16 and 17 are far higher in magnesia than any known living organism, and it is evident that

an original organic deposit must have undergone an enrichment in magnesium carbonate to bring them about. Dana suggested many years ago that coral or other organic sand, while agitated in seawater, probably exchanges a part of its calcium for magnesium, and there is much reason to think that it does. Otherwise, the change must have been brought about by magnesian solutions percolating through the rock and altering it by the replacement process called dolomitization, or dolomization. Much of the silica, no doubt, results from radiolarians and sponge spicules, but much also, together with the alumina, from fine fragmental sediments.

Origin. Much the greater number of the important limestones are of marine origin, but in certain geological formations freshwater ones are well developed. The calcareous remains of organisms have been their principal source, and of these the foraminifera, the corals, and the molluscs the chief contributors. Their shells have often become thoroughly comminuted to a calcareous slime before final deposition, so that the resulting rock affords no trace of organic structure. The solubility of the carbonate of lime aids in the cementation of the slime to rock and tends to efface the organic characters. Limestones pass by insensible gradations through more and more impure varieties into calcareous shales and marls, but, as a rule, they are deposited in deeper water than the true shales and sandstones. This conception must not be applied too strictly, because, beyond question, a depth of a few feet has often sufficed, and too much emphasis has often been placed upon the depth regarded as necessary for limestones. Coral sands accumulate on or near the immediate shore, and may even be heaped up by the wind.

In confined estuaries of sea water subjected to evaporation, enough carbonate of lime is precipitated directly from solution, to yield important strata, and such are often met in a series of beds associated with rock salt and other precipitated rocks as later set forth. Calcareous deposits from limy springs may also almost reach the dignity of rocks, and when abundant are called travertine or calcareous tufa. If particles of dust, etc., are suspended in limy springs or in concentrated estuarine waters, they gather concentric shells of the carbonate and may yield oölitic deposits from the coalescence of the concretions. Some algæ likewise secrete oölitic calcite and contribute extensively to rocks.

Mineral Composition. Varieties. Calcite is the chief mineral of

limestones, and when thin sections are magnified it exhibits its characteristic cleavages. Dolomite and siderite accompany it frequently, and their molecules also replace the calcium carbonate, in a greater or less degree, to form double carbonates. An unbroken series can readily be traced from pure calcium carbonate, through more and more magnesian forms, to true dolomite. Those with over 5% MgO are usually described as magnesian limestone, and when the MgO mounts well toward the 21.72% in the mineral dolomite, we use the latter name. In the same way, a series of ferruginous varieties may be established toward the clay ironstone and black-band ores, and a siliceous series toward the flints and cherts. Cherty limestones are a very common variety, and are referred to again in connection with chert. When the argillaceous or clayey intermixtures enter, argillaceous or hydraulic varieties result that are generally drab and close-grained, and are useful in the manufacture of cement. Bituminous matter may be present, making the limestones black, and this, in the form of asphalt, may yield asphaltic varieties.

Besides these varieties established on the basis of chemical composition, special names may be given because of structure. Thus earthy limestones tend to crumble to dirt; oölitic limestones resemble the roe of fish; pisolitic varieties consist of concretions of size comparable with peas; and other terms are employed, that are self-explanatory. Prominent fossils suggest names, such as crinoidal, from fossil crinoids; coralline, foraminiferal and many more of local or stratigraphic significance. Practical applications play a part in nomenclature, supplying "waterlime," "cement-rock," "lithographic limestone," etc.

Metamorphism. Limestones feel the effects of metamorphism with exceptional readiness and under deforming stresses, probably accompanied by elevation of temperature, and in the presence of water, or along the contacts with intruded dikes and sheets of igneous rocks, they lose their sedimentary characteristics, such as bedding-planes and fossils, and change into crystalline marbles. The contained bituminous matter becomes graphite; the alumina and silica unite with the lime, magnesia and iron to give various silicates. Other oxides together with the bituminous ingredients contribute to the various colorations. Mechanical effects are manifested in flow lines, brecciation and other familiar features of many that are cut and polished for ornamental stones. Impure

limestones that undergo these metamorphic changes are the most prolific of all rocks in variety and beauty of minerals. Arendal, Norway, and the crystalline limestone belt from Sparta, N. J., north through Franklin Furnace are good illustrations. The crystalline limestones will be again mentioned under the metamorphic rocks.

Occurrence. Limestones are too common to deserve special mention as regards occurrence. They are common rocks in all parts of the country, but the Trenton limestone of the Ordovician, the Niagara of the Silurian and the Sub-carboniferous limestones of the Mississippi Valley are specially worthy of note.

III. Remains of Organisms not Limestones.

Calcareous remains are much the most important of the contributions made by organisms to rocks, but there are others, respectively, siliceous, ferruginous and carbonaceous, that deserve mention.

Siliceous Organic Rocks.

The principal members of this group are infusorial or diatomaceous earths; siliceous sinters; and cherts, hornstones or flints, the three last names being practically synonymous. Infusorial earths consist of the abandoned frustules of diatoms, which are microscopic organisms belonging to the vegetable kingdom. Though not a common rock, they yet are met in series of sedimentary strata, both freshwater and marine, with sufficient frequency to justify their mention. Some foreign earthy materials are unavoidably deposited with them. The siliceous sinters are extracted from hot springs by algæ that, as shown by W. H. Weed, are capable of living and secreting silica in waters up to 185°F. They are far less important geologically than the infusorial earths. Chert is a rock consisting of chalcedonic and opaline silica, one or both. It possesses homogeneous texture and is usually associated with limestones, either as entire beds, or as isolated, included masses. It often has druses of quartz crystals in cavities, and in thin sections under the microscope it sometimes exhibits sponge spicules. Cherts not provided with these organic remains may be regarded with great reason as chemical precipitates, and as American varieties in the great majority of cases lack them the cherts receive more extended mention under the chemical precipitates.

Infus. Earths.	SiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	CaO.	MgO.	Na_2O.	K_2O.	H_2O.
1.	91.43	2.89		0.66	0.36	0.25	0.63	0.32	3.8
2.	86.90	4 09		1.26	0.14	0.51	0.77	0.41	5.99
3.	75.86	9.88	2.92		0.29	0.69	0.08.	0.02	8.37
Silic. Sinter.									
4.	89 54	2.12		tr.	1.71	tr.	1.12	0.30	5.13
Chert.					$CaCO_3$.	$MgCO_3$.			
5.	34.0	0.80			63.4	1.5		0 3	

1. Miocene, Little Truckee River, Nev., R, W. Woodward, 40th Parallel Survey, I. opposite p. 542. 2. Fossil Hill, Nev., *Idem.* 3. Richmond, Va., M. J. Cabell, Mineral Resources, 1883–84, p. 721. 4. Deposit from Old Faithful, Yellowstone Park, J. E. Whitfield, for W. H. Weed, 9th Ann. Rep. Dir. U. S. Geol. Sur., 670. 5. Cretaceous chert, England, Jukes-Brown and Hill, Quar. Jour. Geol. Soc., Aug, 1889.

Comments on the Analyses. The infusorial earths are fairly high in water, and this is the main cause of low silica, but, as stated above, their growth and accumulation in water make it unavoidable that more or less clay and other sediments should mingle with them. In these and the other members of the series, it is important to understand that much of the silica is opaline, or amorphous, hydrated silica, and not quartz or chalcedony. Tests of the amounts soluble and insoluble in caustic alkali are usually made to determine the proportions of the two, for, while it is not an accurate separation—quartz and chalcedony being themselves somewhat soluble—it gives an approximate idea. No. 4 is a deposit separated from the geysers by algæ. No. 5 is largely due to sponge spicules, mixed in with chalk, and therefore is high in calcic carbonate.

Mineralogical Composition. Varieties. The mineralogy of the infusorial earths can be stated less definitely than the chemical composition. The individual diatoms are very minute, but the analyses indicate both opaline and chalcedonic silica as being present. In the sinters and cherts, when the latter can be recognized as organic, the same two varieties are recognizable, and with them are varying amounts of calcite. The infusorial earths are fine, powdery deposits, resembling white or gray dried clays, but they lack plasticity and are best recognized with the microscope. Siliceous sinters, often called geyserite, are cellular crusts and fancifully shaped masses that closely resemble calcareous tufas, but that are readily distinguished by their lack of effervescence. Chert is dense, hard and homogeneous, and of white, gray or black color. It readily strikes fire with steel, and when it breaks has a splintery or conchoidal fracture. It is often decomposed to powdery silica on

the outside, and in extreme cases may yield rather large deposits of this powder, that are called "tripoli," and are used for various practical purposes. Mention may again be made of the cherts that seem best explained by chemical precipitation.

Metamorphism. The cherts alone of these rocks are of sufficient importance to attract attention in this connection, and their metamorphism is briefly referred to on page 293.

Occurrence. Infusorial earths are abundant near Richmond, Va., and on Chesapeake Bay, at Dunkirk, and Pope's Mills, Md. Beds deposited in evanescent ponds or lakes are also well known in States further north. In the West, the Tertiary strata have yielded them in Nevada. In California and Oregon great areas are reported by Diller. Siliceous sinters produced by algæ are quite extensive in the Yellowstone Park, and similar deposits, perhaps caused by the same agent, are found in many hot spring regions. Sinters chemically precipitated also occur. The most important occurrences of chert are all mentioned together on page 293.

Ferruginous Organic Rocks.

It may be questioned if these deserve the dignity of rocks, for they may with great propriety be confined to the minerals distinctively so-called. It will therefore only be mentioned that many have attributed the formation of beds of limonite to the separation of iron hydroxide by low forms of organisms. Even granting this, it is still true that such limonites are insignificant when compared with those that result by purely inorganic reactions in the decay of rocks. Important strata of cherty carbonates of iron are present in the iron mining districts around Lake Superior and have been, no doubt, the principal source of the hematites. Van Hise regards them as probably of organic origin, but the evidence is not decisive and they may be chemical precipitates. Clay-ironstone and black-band ores, that is, argillaceous and bituminous ferrous carbonate, sometimes form continuous beds instead of the usual isolated lenses, but when they do, they are not organic in origin, although decaying organic matter may contribute to preserve the reducing conditions that are necessary to the formation of the ferrous salt.

Carbonaceous Organic Rocks.

When plant tissue accumulates in damp places and under a protecting layer of water that prevents too rapid oxidation, new ac-

cessions may more than compensate for loss by decay so that extensive deposits may result. These become progressively rich in carbon by the loss of their other elements and yield beds of considerable geological, but much greater practical importance. The course of the changes and the several stages are indicated in the following table.

	C.	H.	O.	N.	Total.
Woody Tissue	50	6.	43	1.	100.
Peat	59	6.	33.	2.	100.
Lignite	69	5.5	25.	0.8	100.3
Bituminous Coal	82	5.	13.	0.8	100.8
Anthracite	95.	2.5	2.5	trace.	100.

The changes are in the nature of loss of oxygen and hydrogen, and also of carbon, but the decrease of the first two is relatively so much greater, that the carbon actually is enriched. The table is theoretical in that no account is taken of the more or less fortuitous mineral matter that forms the ash together with a small percentage of incombustibles in the vegetable tissue itself. Peat is a more or less incoherent mass of twigs and stems, decidedly carbonized and darkened, but with the original structures, as a general rule, still well preserved and recognizable. By gradual stages it passes into lignite, which is still further compacted, and which exhibits the original structures more faintly. In bituminous coal, they are seldom recognizable, and the aggregate is compact and black. In anthracite the coal is dense, amorphous and lustrous. The oxidation necessary to the latter varieties may have been largely performed before actual burial in other rocks, but the changes are continuous and progressive in all.

Other organic derivatives, such as asphalt, petroleum, etc., are not considered of sufficient abundance to rate as rocks.

Metamorphism. Anthracite is locally produced from bituminous coal, near igneous intrusions and by regional metamorphism, as later explained. The chemical changes are the same as those progressive ones above outlined, but are doubtless more rapidly brought about. Anthracites become graphitic, and, as a theoretical extreme, pass into graphite. Natural cokes are also produced along intruded dikes.

Occurrence. Peat favors cool and moist latitudes in all parts of the world, and is chiefly of fresh water origin. Lignites and coals are best developed in the Carboniferous and Cretaceous strata, and

where the former occur in the East and the latter in the West, they often contain coal seams.

III. Precipitates from Solution.

The name of this group indicates the character of the rocks that comprise it. Bearing in mind the condition established at the outset, p. 38, that a rock should form an essential part of the earth, it is evident that water is the only natural solvent abundant enough to yield such rocks, and that only the most widespread compounds that are notably soluble in it, or in its common solutions of other more soluble salts, can meet this requirement. The rocks may be conveniently taken up under the following heads. 1. Precipitates involving the alkaline earths and alkalies. 2. Siliceous precipitates. 3. Ferruginous precipitates.

Precipitates Involving the Alkaline Earths and Alkalies.

The carbonate of lime in stalactites, stalagmites and crusts on the walls and floors of caves in limestone or in the surface deposits from limy springs affords a rock of this character, that is a form of limestone, from pure varieties of which it does not differ in composition, although its banded structure and rings of growth which we may describe by Posepny's useful word "crustification," in a measure distinguish it. Naturally such deposits are often beautifully crystalline, free from admixture except of associated dissolved materials and as a rule purer than sedimentary limestones. They yield our well-known onyx marbles. Some regularly stratified deposits of limestones that are associated with the precipitated rocks next discussed have doubtless originated together with them.

Gypsum and Rock Salt are the chief members of this sub-group. They occur quite invariably in association, and have resulted alike from the evaporation of sea-water and from the drying up of lakes, originally fresh. Both are mixed more or less with dust and other mechanical sediments washed or blown into the evaporating reservoir, or are interbedded with other salts that were present in a minor capacity in the mother liquor, but instances of thick beds, especially of rock salt of surprising purity, are well known. When these attain several hundred or even a thousand feet, it is evident that more than twenty-five times this depth of salt water, on the basis of the known composition of the sea, would have to be evaporated, and this is a practical absurdity even for any conceivable

confined body, with occasional renewals from breaches of the barrier. The recent explanation, however, advanced as the "Bar-theory," by Ochsenius*, clears it up. We need only to assume a relatively deep and nearly land-locked estuary, with a shallow bar between it and the sea. Evaporation continually concentrates the confined salt water and especially the portion on the shallow bar. This becoming rich in mineral matter and of high specific gravity, flows inward and down the slope of the bar to the bottom of the estuary. In the course of time, and allowing for the influence of pressure in the depths and of temperature, conditions favorable to precipitation, first, of the insoluble gypsum, later of the more soluble common salt will be reached, and in varying and alternating layers they will be built up indefinitely, or until some upheaval or subsidence alters the relations of the estuary to the sea. The most soluble ingredients, such as KCl, $MgCl_2$, $MgSO_4$, etc., become continually richer in the mother liquor, and unless this is finally evaporated too, they escape and are not found in the series. So far as we know, the Stassfurt district, in Germany, is almost the only place where this escape has been prevented on a large scale, although rock salt is of world-wide distribution.

Gypsum forms at times gray or black earthy beds, that look very much like limestone, but of course do not effervesce. Again, it is in white, cream-colored or deeper-tinted layers, yielding alabaster. Minor portions afford selenite, the clear, transparent variety, and thin coats of native sulphur are seldom lacking. Rock salt forms crystalline beds, often stained red or brown, by iron-oxide. Both gypsum and salt may impregnate associated sediments more or less, yielding gypseous or saline shales and marls.

Metamorphism. None of the above rocks are worthy of mention as regards metamorphism.

Occurrence. In America, gypsum is found especially in the Upper Silurian of New York; the Lower Carboniferous of Michigan and Nova Scotia; the Triassic in the Eastern prairie states, Kansas and Texas; in undetermined Mesozoic in Iowa, and in the Jura-Trias or in undetermined strata in Colorado, Utah and the West. Rock salt occurs in the Upper Silurian of southern New York; in the Triassic of Kansas; in the Quaternary (?) of Petite Anse, La., and at many places of recent geological age in the West.

* *Zeitschrift f. Praktische Geologie.* May and June, 1893. An excellent abstract by L. L. Hubbard appears in the Geol. of Michigan. V. Part II., p. ix.

SILICEOUS PRECIPITATES.

Geyserite.	(a)SiO_2.	(b)SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	K_2O.	Na_2O.	H_2O or Loss.	Sp.Gr.
1.	81	95	6.49	tr.	0.56	0.15	0.65	2.56	7.50	
Cherts.										
2.		99.46		0.29	0.4	tr.			0.34	
3.	3.35	95.78		0.16	tr.	0.01			0.20	
4.	4.52	93.65		0.83	0.05	0.01			0.78	
5.		98.10	0.24	0.27	0.18			0.23	1.16	
6.		94.91		2.85	0.42	tr.				
Sil. Oölite.										
7.		95.83		2.03	1.93	tr.				2.63
					$CaCO_3$.	$MgCO_3$.				
8.		56.50		1.50	16.84	2.60			12.54	2.688
9.		3.70		1.42	88.71	8.09				2.654
Cherty iron carbonates.					CaO.	MgO.	FeO.	MnO.		CO_2.
10.		58.23	0.06	5.01	0.38	9.59	18.41	0.25	2.08	5.22
11.		46 46	0.24	0.64	1.87	3.10	26.28	0.21	1.22	19.96
12.		28.86	1.29	1.01	0.74	3.64	37.37	0.97	0.68	25.21

NOTE. (a)SiO_2 means silica soluble in caustic alkali; (b)SiO_2, silica insoluble in the same.

1. Geyserite, Splendid Geyser, Yellowstone Park, J. E. Whitfield for W. H. Weed, *9th Ann. Rep. Dir. U. S. Geol. Surv.*, 670. 2. Gray unaltered chert, Joplin, Mo. Analysis made by U. S. Geol. Surv. Quoted in *Ann. Rep. Geol. Surv. Ark.*, 1896, III. 161. 3. White altered chert, Galena, Kan., *Idem.* 4. Unaltered chert, Bellville, Mo., *Idem.* 5. Decomposed chert, or Tripoli, Seneca, Mo., W. H. Seamon. Quoted by E. O. Hovey, *Amer. Jour. Sci.*, Nov., 1894, 406. 6. Chert, Roaring Springs, Newton Co., Mo., J. D. Robertson, for E. O. Hovey, *Idem.* 7. Siliceous oölite, Center Co., Penn., Barbour and Torrey, *Amer. Jour. Sci.*, Sept., 1890, 249. 8. Silica-lime oölite, *Idem.* 9. Lime-silica oölite on same specimen as No. 8, *Idem.* 10, 11. Cherty iron carbonates, N. E. Minn., T. M. Chatard, for C. R. Van Hise, *Monograph XIX, U. S. Geol. Survey*, 192. 12. Cherty iron carbonate, Sunday Lake, Gogebic Range, Mich., W. F. Hillebrand, *Idem.*

Comments on the Analyses. The first seven are high in silica, some approximating chemical purity. No. 1 has admixtures of mud thrown out by the geyser from its walls. The five cherts 2–6 inclusive have but slight amounts of alumina, iron and lime, and low percentages of water. Nos. 3 and 4, by the determinations of soluble silica give us some idea of the amount of the opaline form that is present. The three analyses 7, 8 and 9 are a most instructive series, passing as they do from nearly pure silica into a moderately siliceous, magnesian limestone, from which the first two are thought to have been derived by replacement. Nos. 10, 11 and 12 are the curious cherty carbonates of iron from which the Lake Superior iron ores have been formed by subærial decay. Their richness in magnesia as compared with lime is noteworthy.

Mineralogical Composition. Varieties. Cherts are so exceedingly fine grained that they give no indication of their constituent minerals to the unaided eye. The microscope shows, however, that they are chiefly chalcedony in excessively minute crystals, with which are associated varying amounts of opaline silica, quartz crystals, calcite or dolomite rhombs and dusty particles of iron oxide. In foreign cherts as stated above on p. 286, sponge spicules have been met, but not in the important American varieties. Cherts often have an outer powdery crust due to decomposition, and while as shown by analysis 5, this may not mean any notable chemical change, it may penetrate whole beds and leave only a white incoherent mass called "tripoli," that is used for a polishing powder and for various other purposes. Cherts have spherulites occasionally and are still more often oölitic. The cherty or siliceous rocks of the formations containing the Lake Superior iron ores are mixtures of chalcedonic silica and carbonate of iron in varying proportions, and in their decay they afford more or less sharply differentiated jaspers and hematites. Three analyses of varying composition are given above, Nos. 10, 11 and 12.

As stated earlier, cherts are intermingled in all proportions with limestones. They are very puzzling problems as regards origin. Where devoid of organisms, the majority of observers regard them as in some way precipitated chemically from sea water, possibly by way of replacement of limestone. Their structure and relations give us few definite clues on which to base a firm conclusion. As earlier stated, others regard them as derived from siliceous remains of organisms, such as sponges, radiolarians and the like, which may have been redissolved and worked over into chalcedony, making them practically precipitates. Cherts are also called hornstone and flint.

Metamorphism. Purely siliceous cherts are unpromising subjects for metamorphism, except as they yield silica in cherty limestones for the production of silicates. The ferruginous cherts of Lake Superior pass into actinolitic and magnetitic slates, a most interesting change, especially in the former case. The lime, magnesia and iron are combined with silica under the metamorphosing influences, so as to yield the actinolite.

Occurrence. The abundance of cherts or related rocks in the region of Lake Superior, either associated with limestone or in the cherty carbonates described above is remarkable. In their eco-

nomic products, they are the most important strata present. The Siluro-Cambrian limestones are often cherty both east and west, and in the New York and Ohio Devonian, the so-called "Corniferous" limestone was named from its richness in "hornstone." In the Mississippi Valley the lower Carboniferous strata are particularly prolific in cherts.

Ferruginous Precipitates.

Some iron ores doubtless originate in this way, and the processes by which the soluble proto-salts are oxidized and precipitated as the insoluble ferric hydroxide are well understood. But they may be considered rather as minerals than as rocks. The cherty iron carbonates of the preceding section have already been cited, and the clay ironstones and black band iron ores are omitted from further mention for the same reasons as are the limonites.

The Determination of the Aqueous and Eolian Rocks.

The members of this series are much easier to recognize than are the igneous. Breccias, conglomerates and sandstones are at once apparent from their fragmental character. Breccias differ from conglomerates in the angular shape of their component fragments. As the sandstones become finer, the argillaceous varieties may be distinguished by the peculiar odor emitted by all clays and clayey rocks when breathed upon. The calcareous sandstones and marls betray themselves by effervescence with acid. All limestones, unless too rich in magnesia, effervesce in cold acid, and the more readily if first scraped up into a little heap of powder with a knife. Dolomites effervesce much less readily, and warm acid may be necessary. Infusorial earth may need the microscope for its certain identification, and then the abundance of the little organisms is very apparent. The cherts are so characteristic in appearance as to admit of little uncertainty, except as compared with the silicified tuffs and excessively fine felsites, called petrosilex, in which case geological surroundings or the microscope are the only resources. The ferruginous rocks, if such be allowed, are self-evident, as are the carbonaceous. Gypsum is easily recognized when in the crystalline form, but when black and earthy, the observer may be forced to determine its lack of effervescence, and to make a sulphur test with the blowpipe.

For field work and travel, it is well to appreciate that a few dry

crystals of citric acid, that can be dissolved in a little water as needed, serve very well for tests of effervescence. They are more safely carried than are liquid mineral acids.

(*To be concluded in the July number.*)

BOOK REVIEWS.

A Text-book of Gas Manufacture for Students. By JOHN HORNBY. 1896. George Bell & Sons, London, and Macmillan & Co., New York. $1.50. Cloth binding, good quality of paper and typography; 261 pages, 62 illustrations and six large inset plates.

This work is one of a series of technological handbooks and was prepared to serve as a manual suitable to the requirements of young men just starting their training in gas works.

The author treats the subject in an entertaining and attractive manner, sufficiently exhaustive for the purpose. The various apparatus employed to manufacture and convey gas are described in detail, many illustrations being used.

The discussions of the proper coals to use, the description of carbonization, the effect of temperature, the purification of the gas, the methods of ascertaining its purity and power and of controlling the pressure, the laying of pipes and construction of meters and burners, are all ably handled, affording an excellent treatise.

The work concludes with a discussion of the composition and enrichment of coal gas and the manufacture of sulphate of ammonia.

The author is to be commended for producing a popular work which ably fulfills the purpose for which it was written, and at the same time is sufficiently comprehensive to afford the general reader an excellent idea of the entire subject. J. S.

Coke. A Treatise on the Manufacture of Coke and the Saving of By-Products. By JOHN FULTON, E. M. The Colliery Engineer Co., Scranton, Pa. 1895.

A work on this subject is especially needful at this time on account of the efforts now being made to introduce into the United States the modern type of retort coke ovens, with their auxiliary apparatus for saving the chief by-products, tar and sulphate of ammonia, from the gases expelled during coking.

Much of this work has appeared in a number of papers written by the author in the Colliery Engineer and Metal Miner, and as used in the preparation of this volume they have been carefully revised.

The subject is discussed as follows:

CHAPTER I. The coal fields of the United States, geographically and geologically described, including many analyses.

CHAP. II. is devoted to the physical and chemical properties of coal.

CHAP. III. embraces the preparation of coal for the manufacture of coke, describing the various breaking, washing and jigging machines.

CHAP. IV. describes the initial methods of coking in the open air or in partially closed ovens, coking in pits, in the Bee-Hive ovens both old and new styles. The Thomas, Welsh, McLanahan and Browney ovens are fully described, aided by many illustrations.

CHAP. V. takes up the retorts and the ovens constructed to save the by-products and gives the foreign and domestic practice both old and new.

The following ovens are described in detail:

The Belgian, Coppée, Appolt, Simon-Carvé, Siebel, Otto-Hoffman, Semet-Solvay, Huessner and others. Dr. Bruno Terne has furnished a discussion on the "Utilization of the By-Products of the Coke Industry." This chapter is the most important and covers nearly a hundred pages.

CHAP. VI. is devoted to the physical properties of the three principal fuels used in metallurgical operations.

CHAP. VII. discusses the laboratory methods of determining the relative calorific values of metallurgical fuels. The tests here quoted relate mainly to density determinations.

CHAP. VIII. deals with the location of plants for the manufacture of coke.

CHAP. IX. gives general conclusions on the work, cost and products of several types of coke ovens. The volume closes with an appendix devoted to the discussion of the manufacture of coke by the various systems, both in the United States and abroad.

The author's style is rather stilted in expression, a criticism of lessened value from the nature of the work, it being of a technological character.

The work contains much of value to those interested directly in the industry or theoretically engaged in the study of the subject, although it is rather weak along the chemical side of the discussions and many omissions are apparent,—notably that of calorimeters under the chapter devoted to laboratory methods.

There are 342 pages well illustrated by ninety drawings, many of which are large inset plates. The topography and paper are of good quality and the illustrations are clear and well defined. The work is well bound in cloth. J. S.

California Gold Mill Practices. Bulletin No. 6 of the California State Mining Bureau. By ED. B. PRESTON, M. E. Sacramento. A. J. Johnston, Supt. State Printing. 1895. 85 pp. Paper covers. Typography and paper of fair quality. (This work is issued free to inhabitants of the State of California who send three cents for postage with their application. To others the price is fifty cents.)

This work, although small in size, gives much useful data on the construction of gold-milling plants, dealing with the location, arrangement, construction, mechanical appliances and manipulation. The practice described is modern. Special attention is called to the articles on sampling, assaying and concentrating; subjects that are daily becoming more and more important to working mill men. Typical plants located in the different counties of California are briefly described and a complete specification is given of a 40-stamp gold mill driven by water power.

This little work is sufficiently illustrated for its purpose by 51 drawings, some of which are insets of plate size, and will be of general use to mill men and others. J. S.

Lecture Notes on Theoretical Chemistry. By FERDINAND G. WIECHMANN, PH. D. Second Edition. John Wiley & Sons, New York. 1895. 12mo., 288 pp. Cloth binding. Good quality of paper and typography.

The first edition of this work appeared in 1893 and was favorably received. In this later edition the text has been radically changed by rearrangement and by the addition of considerable new matter.

The important bibliography has been retained, having its value increased by the addition of references to works published during the last two years, thus bringing the work up to date.

As the title indicates, the author does not claim to give exhaustive discussions of the subjects treated. It has been his aim to present a general view of the extensive field of chemical theory, treating the subjects as concisely as thoroughness would permit. For the benefit of those desiring more extensive research, the list of works on theoretical chemistry is appended.

The subject matter is ably presented as follows: Chap. I, Introduction and Properties of Matter; Chap. II., Specific Gravity of Solids, Liquids and Gases; Chap. III., Science of Chemistry; Chap. IV., Chemical Notation and Nomenclature; Chap. V., Chemical Formulæ and Equations; Chap. VI., Atoms, Atomic Mass and Valence; Chap. VII., Periodic Law; Chap. VIII., Molecules and Molecular Mass; Chap. IX., Structure of Molecules; Chap. X., Stoichiometrical Calculations; Chap. XI., Energy; Chap. XII., Chemical Energy, Photo-chemistry; Chap. XIII., Thermal Energy, Thermo-chemistry; Chap. XIV., Electrical Energy, Electro-chemistry, Bibliography. Much stress is laid upon the value of stoichiometrical calculations, and examples are freely introduced to illustrate the different principles discussed.

The work is meritorious and is unreservedly recommended to those entering upon the study of theoretical chemistry. J. S.

An Introduction to the Study of Rocks. By L. FLETCHER; being one of the guide books to the collections of the British Museum. London, 1895, 6d.

The above work adds another to the valuable series of introductory handbooks and guides that aid the visitor to understand and appreciate the vast scientific treasures of the British Museum. All who have wandered through the galleries and halls in recent years have felt the indispensable aid that these introductory handbooks have extended. Not alone are they serviceable to the scientific visitor, but to the beginner and to that great class of people who have scientific interests, though engaged in other pursuits, they furnish valuable introductions to the several provinces of the Kingdom of Nature.

Mr. Fletcher in the first half of the work presents, at considerable length, the fundamental questions that arise with reference to rocks, such as their components, their essential characters, their prominent structures and textures, etc. In the course of the treatment two new terms are introduced which are likely to prove serviceable. *Petrical*, from the

Greek for rock, is used for the large characters that appear in great outcrops in the field, *i. e.*, those to which the term structure was restricted in the November *Quarterly*, p. 50. *Lithical*, from the Greek for stone, is applied to the smaller characters of hand specimens for which in the above reference texture was used.

Based on the most striking of the generalities thus presented, Mr. Fletcher essays a preliminary grouping into seven divisions, as follows:

I. *Rocks presenting a directional variety of structure.* Crystalline schists, gneisses, slate, shale.

II. *Rocks essentially composed of material belonging to a single mineral species.* Rock salt, hæmatite rock, quartz rock, calcite rock (chalk, limestone, marble), dolomite rock, serpentine rock.

III. *Rocks which, though really composed of material not belonging to a single definite mineral species, are so far homogeneous in aspect that the essentiality of the compositeness is concealed from the unaided eye.* Clay, coal, obsidian, phonolite, felstone.

IV. *Rocks which are similar in the above character to those of the last group, except that they contain simple minerals porphyritically dispersed through them.* Rhyolite, trachyte, andesite, basalt.

V. *Rocks which are composite in kind of material, holocrystalline and without directional lithical characters.* Granite, syenite, diorite, dolerite, euphotide.

VI. *Rocks having aggregate structure.* Breccia, conglomerate, sandstone.

VII. *Cellular rock.* Lava.

A moment's thought shows that Mr. Fletcher has based this grouping on structural or textural characters to be seen in the specimens and has carefully eliminated all genetic considerations. These divisions are next discussed in detail and it is then brought out that the characters are meant rather to aid the selection of types than to serve as definitions. Then employing the kinds of rocks cited under the above seven divisions as topics, the author discusses the method of origin of each as a further approximation to a natural system. The following groups are then established which are practically the associations that determine the museum arrangement.

I. *Rocks consisting essentially of compounds of carbon and hydrogen.* Coal.

II. *Rocks consisting essentially of a single mineral.* Rock salt, hæmatite rock, quartz rock, calcite rock (chalk, limestone, marble), dolomite rock, serpentine rock.

III. *Rocks showing aggregate structure, but not cleavable.* Breccia, conglomerate, sandstone; clay; shale.

IV. *Cleavable rocks.* Slate.

V. *Rocks which are holocrystalline in structure and show a directionality of the lithical characters.* Crystalline schists, gneisses.

VI. *Rocks which consist of more than one kind of mineral, are holocrystalline in structure and show no directionality of the lithical characters; the groundmass of the porphyritic kinds not being of extremely fine texture.* Granite, syenite, diorite, dolerite, euphotide.

VII. *Rocks in which there is a groundmass with porphyritic enclosures; the groundmass being of extremely fine texture.* Phonolite, felstone, rhyolite, trachyte, andesite, basalt.

VIII. *Rocks which are cellular or of vitreous structure.* Lava, obsidian.

A discussion of the processes by which rocks in general are formed, and then of the mode of origin of basalt, of granite and of the crystalline schists, leads up to the brief description of the museum display by cases.

The clear presentation of the subject of rocks to beginners is not the simplest thing in the world. The series of objects is extremely diverse, and many unrelated processes are involved in their production. In order not to confuse and bewilder students, the teacher must also emphasize the intelligible points and the recognizable characters, and not make the endless reservations and exceptions to general statements that are always lying in wait for him and that confuse the learner. It is the reviewers conviction after some years' experience, that we are not likely to reach a better fundamental classification than the time-honored one of Igneous, Aqueous (or Sedimentary) and Metamorphic, irrational though it be, especially in regard to the last named groups, and that it furnishes a basis for clearer presentation of a complex subject than does one that is essentially based on textural and mineralogical differences.

Mr. Fletcher's work is admirable in the conceptions that it gives of the subject, and after study of the introduction one already fairly familiar with rocks appreciates this to the full, but we think that unless the reader already possesses considerable knowledge of rocks, the generalities will, at times, be less real to him than if they had been stated in the form of systematic comments on the contents of individual cases of specimens assumed to be at the time under the learner's eye. J. F. K.

The Journal of the General Mining Association of the Province of Quebec, Vol. II., 1894–'95, 312 pp. Price to Non-Members $2. B. T. A. BELL, Sec., Ottawa.

The second volume of the above Society forms a neatly printed book with many papers of local or of wider importance. The Society has a goodly number of members and covers a district whose mineral resources are large. The papers in instances are likely to be of value for reference on the part of the readers of the *Quarterly*, and a classified grouping of titles is therefore appended.

Papers on Mineral Resources. Asbestos Industry of Quebec in 1894, J. J. Penhale. Chromic Iron in Quebec, J. Obalski. Chromic Iron, Its Properities, Occurrence and Uses, J. T. Donald. Coal and Lignite around Hudson Bay, R. Bell. Gold Mining in Quebec in 1894, E. B. Haycock. Auriferous Gravels of British Columbia, J. B. Hobson. Hydraulic Mining in British Columbia, G. M. Dawson. Mica Deposits and Mining in the Saguenay District, Quebec, J. Obalski. Mica Mining in Quebec, B. T. A. Bell. Mineral Waters, J. T. McCall. Phosphates, Canadian, Home Manufacture and Market, J. B. Smith. Canada, a Natural Centre for Fertilizer Manufacture, H. Wigglesworth. Phosphate Mining in Quebec in 1894, B. T. A. Bell. Phosphate's Future, R. C. Adams. Phosphoric Acid in Agriculture, F. T. Shutt. Pyrites, Albert Mines and Capelton Chemical Works, S. L. Spafford. Copper Pyrites Mining in Quebec in 1894, John Blue. Slate, Its Extraction and Uses, H. J. Williams.

Papers on Mining. Diamond Prospecting Drill in Mining Canadian Phosphate, J. B. Smith. Electricity in Mining, W. F. Dean. Investments in Mines, R. C. Adams. Canadian Iron Industry, G. E. Drum-

mond. The Magnetic Needle, A. W. Elkins. Mine Tunnels and Mine Timbering, W. A. Carlyle. Ore Sampling, J. T. Donald. Repairs to Rock Drills, A. Sangster, Jr. Repairs to Rock Drills, J. E. Hardman.

The following are on more general scientific subjects: Geological Survey of Canada and its Operations, R. W. Ells. The Igneous Origin of Certain Ore Deposits, F. D. Adams. J. F. K.

Prospecting for Gold and Silver. By ARTHUR LAKES. 202 pp. 98 ills. Cloth, $1.00. The Colliery Engineer Co., Scranton, Penna.

Professor Lakes has endeavored in this book to put in a form intelligible to the miner, prospector and others who have not had the benefit of special technical training, the important points about ores and ore bodies in general and about those in the West in particular. All who are familiar with mining and who take an interest in the active workers that fill the less elevated positions, must have often felt a wish that the latter possessed a little broader and better based knowledge of mining-geology. Professor Lakes seems to us to have succeeded in his attempt to put this matter in such shape that his audience can grasp it. The statements, though simple, are clear and correct, and are the results of many years personal experience and observation. Illustrations from the author's well-known skilful pencil are frequent, although occasionally they could be made more graphic. The map of Stromboli, p. 129, does not convey a very definite impression, and in Plate XXIII., p. 56, the quartz crystal would be truer to Nature if it did not have prism faces, as these are extremely rare or insignificant in the quartzes of igneous rocks.

The constituency aimed at is not a specially easy one to reach with a book, but we hope that this one will find a large circle of readers, as it thoroughly deserves. J. F. K.

Electric Wiring. By RUSSELL ROBB. New York and London, Macmillan, 183 pages. Price, $2.50.

This book consists of an introduction of about fifty pages explaining the general principles of electric circuits followed by the National Code of rules for Electric Wiring, with explanations and comments inserted after each rule. It is this last feature, which is well carried out, that gives the work its originality and value. The fact that the definitions and descriptions accompany each rule is a great advantage to many architects and other non-electrical persons who are likely to use the book. This plan naturally involves some repetition, but this difficulty is more than counter-balanced by the convenience and avoidance of error which it secures.

The particular Code of Rules which forms the basis of the book is unfortunately not adopted universally, and differs somewhat from the other important codes. Furthermore, a conference of delegates from the American Institute of Electrical Engineers, National Electric Light Association, General Electric, Western Union and Westinghouse Companies and other institutions and companies is about to be held in New York City, at which it is expected that a uniform set of rules will be promulgated for general adoption. If any departure is made from those used in the book under review, it will considerably reduce its value. This defect could be corrected, however, by a revised edition or by an appendix.

For the most part the explanatory matter is clear, but is quite element-

ary in character in order to suit it to the majority of its probable readers. The various plans for laying out wiring in actual practice which are so important and at the same time so difficult to find in electrical books and journals are not included in the present work. This omission is much to be regretted, and constitutes a positive fault, since one may reasonably expect such plans to be given in a book on "Electric Wiring."

F. B. C.

Synopsis of Current Electrical Literature. Compiled from Technical Journals and Magazines during 1895. By MAX OSTERBERG, E. E., A. M. New York: D. Van Nostrand Co. 143 pages. Price $1.

The articles on electrical subjects which appear each year are becoming so numerous that an index to them is more than welcome—it is a necessity.

The German publication entitled "Fortschritte der Elcktrotechnik," which began in 1887, is excellent, but is not sufficiently kept up to date to be of any value for current references, the volume for the year 1893 not being completed at the present time. This new work is a rearrangement of the monthly synopses which have appeared in "Electric Power," consequently it can be brought out very promptly as is evidenced by the fact that it was issued within about two months of the close of the year.

All the important articles which have appeared in the American, English, French and German electrical periodicals are referred to, and the electrical articles in mechanical and engineering journals are also included. In addition to a complete index of authors' names, the references are classified very carefully according to subjects, and a short epitome of the general character and scope of the article is given in each case. This feature is most valuable, since it saves the trouble of looking up a great many articles which are not sufficiently described by their titles. The amount of space devoted to each synopsis and the clearness of statement are worthy of special commendation, as both these are matters of peculiar difficulty.

In short, the author has rendered a service which deserves the thanks and support of those interested in electrical literature, and it is hoped that approval will be sufficiently substantial to insure the continuation of this very useful publication.

F. B. C.

Lettering for Draftsmen, Engineers and Students. By CHAS. W. REINHARDT. New York. D. Van Nostrand Co. 1896.

This treatise is a very good one on the subject of freehand lettering. The plates selected to exemplify the text are commendable, and the text explains concisely the important parts of the subject. On the whole the book will rank with the best on this subject.

R. E. MAYER.

ABSTRACTS.

METALLURGY FOR 1894, BY JOSEPH STRUTHERS, PH. D.

REFRACTORY MATERIALS.

The Refractory character of Fire-Clays.—By P. Jochum (Ably discussed).—*Zeits. d. Vereins deutcher Ingeneure*, Vol. 39, p. 53.

Fire-Clays in New Jersey.—By C. Ferry (Descriptive).—*Iron Age*, Vol. 55, p. 332.

High Silica Firebrick.—By Chas. Ferry.—*Iron Age*, October 10th.

Value of Practical Tests of Refractories.—By Chas. Ferry.—*Iron Age*, October 31st.

PYROMETRY.

Wibourg Air Pyrometer.—By H. Pinzger (Descriptive).—*Zeits. Vereins deutch Ing.*, Vol. 38, p. 1547.

Uehling and Steinbart's Air Pyrometer (Description of device for continuous automatic record).—*Iron Age*, Vol. 55, p. 434; *Eng. and Min. Jour.*, Vol. 59, p. 249.

Platinum Resistance Pyrometers.—By C. T. Haycock and F. H. Neville (Description of instruments and methods of use).—*Iron Age*, Vol. 55, p. 434; *Eng. and Min Jour.*, Vol. 59, p. 249.

The Mesuré and Nouel's Optical Pyrometer (Descriptive).—By F. E. Thompson.—*Iron Age*, Vol. 55, p. 374.

Pyrometers (Discussion of the Electric Pyrometer).—*Mfr. and Iron World*, September 27th.

FUELS.

Utilization of Gas from Coke Ovens.—By G. A. Renel (Descriptive of 84 oven plant of Carmuel Mining Co.).—*Genie Civil*, Vol. 24, p. 315.

The Otto Hoffman and Heussner Coke Ovens.—By A. Heussner.—*Stahl u. Eisen*, Vol. 14, p. 1105. (Discussion).—By F. Schneiwind.—*Amer. Manf.* Vol. 56, p. 515.

The Brunck Coke Oven.—By R. Brunck (Descriptive).—*Trans. Federated Inst. Min. Engrs.*, Vol. 9, p. 47.

Semet Solway Coke Ovens.—By J. H. Darby (Descriptive).—*Trans. Federated Inst. Min. Engrs.*, Vol. 9, p. 54.

A New Departure in the Manufacture of Coke (Description of 70 oven plant Simon Carvés type at Newport Iron Works, Eng.—*Coll. Guardian*, Vol. 59, p. 602.

The Semet Solvay Coke Oven (General description. Illus.).—*Eng. and Min. Journ.*, November 30th.

The Semet Solvay *vs.* the Otto Hoffman Ovens. (Discussion).—By John H. Darby.—*Amer. Manuf. and Iron World*, March 29th.

Bee-Hive Oven with recovery of By-Products. (Illustrated Description of English Works).—*Iron Age*, October 3d.

A Competitive Trial of Flue Heated Coke Ovens.—By A. Heussner.—*Iron and Steel Trades Journ.*, September 14th.

Coke Making in the South of Russia. (Method of Manufacture and Cost).—*Amer. Manuf. and Iron World*, September 13th.

Coal and Coke in Upper Silesia.—By Alex. Gouvy.—*Coll. Guard.*, April 26th.

Manufacture of Coal Briquettes.—By Wm. Colquhon (Abstract of papers before the British Institution of Civil Engineers, Illustrated). —*Eng. and Min. Journ.*, October 12th.

Some Fuel Problems.—By Jos. D. Weeks (Address delivered at Atlanta).—*Amer. Manuf. and Iron World*, October 25th.

Charcoal Burning in Canada. (Descriptive of Process).—*Can. Min. Rev.*, Vol. 14, p. 10.

PRODUCERS.

Gas Producers.—By P. Bayard.—(Illust. General description and comparison of working).—*Stahl u. Eisen*, Vol. 14, p. 952.

Decomposition of Water in Gas Producers.—By A. Schmidhammer. (Discussion).—*Trans. Amer. Inst. Min. Eng.*, Vol. 24, p. 804.

Recovery of By-products from Producer Gas.—By A. Gillespie. (General description).—*Coll. Guard.*, Vol. 69, p. 415.

Attempts to Recover By-products from Producer Gas.—By C. Ridgely. —*Jour. Ill. Min. Inst.*, Vol. 3, p. 39.

Producer Gas in the Foundry.—By G. T. Prince. (Advantage in drying cores, moulds, etc.)—*Iron Age*, Vol. 55, p. 325.

The Swindel Producer (Illus.)—*Iron Age*, November 21st.

Smyth Continuous and Self-cleaning Producer (Illus.)—*Iron Age*, July 25th.

CALORIMETRY.

Modern Calorimeters and Their Use.—By Joseph Struthers. (Illus. trated and descriptive, dealing principally with the modern calorimeters of Thompson & Mahler).—*S. of M. Quar.*, Vol. 16, No. 3.

Junkers' Gas Calorimeter. (Illus.)—*Industries and Iron*, Vol. 18, p. 390.; *Engineering*, Vol. 59, p. 574.

Calorimeter for Coal.—By R. C. Carpenter.—*Amer. Soc. Mech. Engrs.; Amer. Mach.*, October 31st, p. 870.

ORES OF IRON.

The Mesaba Range.—(Illustrative and descriptive).—*Iron Age*, August 1st, 8th, 22nd.

Production of Iron Ores in the United States, 1894.—By John Birkenbine (From Mineral Industries, Vol. III.)—*Iron Age*, November 21st.

PIG IRON.

Selections of Materials for the Blast Furnace. By R. E. Chambers. (General formulæ given for determining values of iron ores, limestone and coke, based on Gordon's Methods).—*Trans. Min. Soc., Nova Scotia.* Vol. 3, p. 68.

Fine Ore in the Blast Furnace.—By F. B. Richards (General discussion cites case of a 16 by 75, Pittsburg furnace using five-sixths of this ore, yielding 250 tons of iron per day with less than 2,000 lbs. coke per ton.—*Iron Trade Review*, Vol. 28, p. 42.

Charcoal Blast Furnaces.—(Description of Gladstone, Mich., Furnace).—*Iron Trade Review*, Vol. 28, p. 42.

New Lines for a Blast Furnace.—By J. W. Thomas (Proposed contracting shaft midway and there introducing superheated steam.—*Iron Age*, Vol. 55, p. 387.

Formation of Cyanides in the Blast Furnace,—By C. H. Meissner (Collection of notes).—*Proc. Ala. Ind. and Scientific Society*, Vol. 4, p. 68.

Tuyeres (General remarks on construction and use.—*Iron Age*, Vol. 55, p. 165.

Blast Furnace Top.—By F. B. Richards (Ill. Expansion of flue at furnace top with explosive doors.—*Iron Trade Review*, Vol. 28, p. 27.

Freeing Furnace Gas from Dust.—By U. le Verrier (General discussion).—*Le Genie Civil*, Vol. 26, p. 164.

New Hot Blast Stove.—By W. S. Berner (Air drawn through by injectors).—*Glückauf*, Vol. 31, p. 168.

Desulphurization of iron.—By A. de Vathaire (Uses alkaline metals to remove sulphur from molten iron).—*Revue Univ. des Mines*, Vol. 27, p. 313.

Manufacture of Pig iron in Germany.—By Weinlig (Statistics as to yield, ores, fuel, etc.—*Stahl u. Eisen*, Vol. 15, p. 140.

Foundry Pig iron in Germany.—By C. Müller (Progress since 1892).—*Stahl u Eisen*, Vol. 15, p. 146.

The Iron Industry in Upper Silesia.—By A. Gouvy (Extensively illustrated description with maps.)—*Bul. de la Soc. de l' Ind. Min.*, Vol. 8, p. 333.

Blast Furnace Industry in Upper Silesia since 1882.—By M. Boecker (General description).—*Stahl u. Eisen*, Vol. 15, p. 132.

Manufacture of Iron in the United States.—By J. Birkinbine (Description with 30 photographic views).—*Cassier's Magazine*, Vol. 7, p. 23, 129, 249.

The Blast Furnace.—By E. C. Potter (Short and popular account).—*Can. Min. Rev.*, Vol. 13, p. 231.

Apparatus for stopping the Taphole of Furnace (Ill.)—*Iron Age*, November 21st.

Basic Bessemer Pig Iron.—By Schilling (Analysis and discussion).—*Stahl u. Eisen*, Vol. 15, p. 134.

Magnesia and Sulphur in Blast Furnace Cinder.—By F. Firmstone.—*Trans. Amer. Inst. Min. Engrs.*, Vol. 24, p. 498.

Magnesia and Sulphur in Blast Furnace Slags.—By A. D. Elbers (Discussion).—*Eng and Min. Jour.*, Vol. 59, p. 52.

Use of Dolomite in the Blast Furnace.—By E. K. Landis (Discussion by Firmstine, Ledebur and others).—*Trans. Am. Inst. Min. Engrs.*, Vol. 24, p. 889.

Adulterated Portland Cement and Blast Furnace Slag.—By A. D. lbers.—*Eng and Min. Jour.*, July 6.

Blast Furnace Construction and Working in Upper Silesia.—By A. Goury.—*Amer. Manuf. and Iron World*, June 14.

Advances in Modern Iron Smelting.—By J. Birkinbine (Descriptive).—*Eng. and Min. Jour.*, June.

Application of Blast Furnace Gases to Gas Engines.—*Coll. Guard.*, July 26.

Sulphate of Ammonia Production at Blast Furnaces.—(Record of Economics at Scotch Furnaces).—*Amer. Manuf. and Iron World*, July 5.

The Chemistry of Pig Iron and Its Application to Casting for Electrical Purposes.—By B. S. Summers.—*Elec. Eng.*, June.

Utilization of Blast Furnace Cinder.—By S. Norton.—*Iron Age*, Apr. 18.

Blast Furnace Slag Cement.—*Eng and Min. Jour.*, July 6, p. 8.

Fine Ores in Blast Furnace.—By F. B. Richards.—*Iron Trade Review*, Jan. 3.

Furnace Dust Catcher Refuse.—By W. B. Phillips.—*Iron Trade Review*, Mar. 21.

IRON.

The History of Iron (Notes from Dr. Ludwig Beck's Geschichte des Eisens in seinem technologischen und culturhistorischen Beziehung).—*Iron Age*, March 28th, April 4th, 18th, May 2d, 16th, June 6th, July 27th, August 1st, 15th, September 19th, October 3d, 17th, November 7th.

FOUNDRY PRACTICE.

Strength of Mixtures of Cast Iron.—By T. D. West.—*Iron Age*, Vol. 54, p. 743. Discussion.—By G. C. Henning.—*Iron Age*, Vol. 54. p. 938.

New Cupola with Adjustable Air Inlet (Adjustable Air-tight Round Box).—*Iron Age*, Vol. 54, p. 616.

Moulding.—By S. Bolland (Comparison of green with dry sand moulds). *Iron Age*, Vol. 55, p. 55.

Cast Iron Chilled Wheels.—By W. W. Lobdell.—*Paper of U. S. Assn. of Manuf. of Chilled Car Wheels.*

Pipe Founding (Illustrated description).—*Iron Age*, Vol. 55, p. 51

Foundry Casts.—By A. Sorge, Jr. (Brief general discussion).—*Iron Age*, September 5th.

Natural or Suction Draft Cupolas.—By Thos. D. West.—*Iron Trade Rev.*, June 13th.

History of Iron Founding.—By L. Beck.—*Stahl u. Eisen*, Vol. 14, p. 884.

First Iron Casting in America.—By A. Spies. (Iron kettle cast at Lynn, Mass., 1642).—*Cassier's Magazine*, Vol. 7, p. 65.

MALLEABLE CAST IRON.

Methods of Manufacture and Properties.—*Trans. Amer. Soc. Civ. Engrs.*, Vol 34, No. 1, p. 1; *Ry. Rev.*, August 31st.

Malleable Cast Iron.—By H. R. Standford. (Its manufacture and properties. Illustrated).—*Iron Age*, August 15th.

MALLEABLE IRON.

Calorific efficiency of the Puddling Furnace.—By L. Cubillo (Discussion with reference to remelting pig-iron).—*Journ. Iron and Steel Inst. 1895*, No. 1, p. 412.

Value of Waste Cinder Heaps.—*Engineer*, Vol. 79, p. 17.

Direct Puddling of Iron.—By Emile Bonehill.—Paper before the Iron and Steel Institute.—*Iron Age*, September 12th.—*Iron and Steel Trades Journ.*, August 24th.

Iron Puddling in Upper Silesia with description of New Gas Fired Furnaces. Illustrated, (Abstract of paper by Alex. Gouvey).—*Coll. Guard.*, August 2d.

Manufacture of Wrought Iron Goods in Russia.—By N. Labzin.—*Stahl. u. Eisen*, Vol. 14, p. 1019.

FORGE AND MILL WORK.

Eighteen-Inch Three High Roll Train. (Illustrated. Descriptive). *Amer. Manuf.*, Vol. 46, p. 728.

New German Rolling Mill (Illustrated, Dortmund Works).—*Stahl u. Eisen*, Vol. 15, p. 53.

The Morgan 1000 Ton Forging Press (Illustrated, 36 inches in diameter).—*Iron Age*, Vol. 54, p. 741.

Electric Power in the Iron Industry. (General Discussion).—*Eng. Mag.*, 1894, p. 406.

The Huber Transfer Table for Rolling Mills—(Illustrated).—*Iron Age*, October 24th.

STEEL.

The Hardening of Steel.—By H. M. Howe.—*Eng. and Min. Journ.* August 24th.

Relation between the Temperature and the Grain of Steel.—By H. M. Howe and A. Sauveur.—*Eng. and Min. Journ.*, December 7th.

CRUCIBLE STEEL.

Russian Tool Steel from the Pontiloff Works (Descriptive).—*Revue Univ. des Mines*, Vol. 38, p. 305.

The Manufacture of Tool Steel.—By A. Ledebur (Describes works in Styria and Lower Austria).—*Stahl u. Eisen*, Vol. 15, p. 1.

Crucible Steel Ingots for Tool Manufacture.—By S. Kern (Special moulds to overcome piping).—*Chem. News*, Vol. 71, p. 187.

Use of Aluminium.—By S. Kern (Strongly advises the use of Ferro Aluminium for small castings).

OPEN-HEARTH STEEL.

Open-Hearth Steel Furnaces.—By B. Dawson (Discusses different types).—*Cleveland Inst. of Engineers' Proceedings*, 1894, p. 10.

New Form of Regenerator Furnace.—By A. Charneau (Dispenses with checker work, uses long flues).—*Engineer*, Vol. 79, p. 17.

Open-Hearth Steel Plants (Description of European Practice).—*Iron Age*, Vol. 54, p. 108, 220, 851, 940, 1054, 1111, 1159.

Steel Works in the United Kingdom (Detailed description).—*Engineering*, Vol. 59, p. 427, 535, 623, 755.

Steel Making Experiments.—By H. S. Fleming (General Article).—*Manufacturers Record*, September 13th.

Notes on Modern Steel Works Machinery.—By Jas. Riley (Abs. of Paper read before the Inst. of Mech. Engrs., Glasgow).—*Can. Min. Rev.*, September.

Steel Works at Round Oaks (Illustrated and descriptive).—London *Eng.*, September 13th.

Recent Progress in Siemens-Martin Furnace Construction.—By Ch. Waldron (notes).—*Indian and Eastern Engineer*, August 10th.

Open Hearth Plant and Plate Mill of the Illinois Co. (Well illustrated with many drawings and supplements).—*Iron Age*, July 25th.

Desulphurizing in the Basic Open Hearth.—By E. H. Samter.—*Iron and Coal Trade Rev.*, May 17.

A Crystallized Slag.—By A. Harpf (Fayalite Composition).—*Oest Zeits. Jür. B. u. H. wesen*, Vol. 43, p. 75.

Manufacture of Tin Plates.—(Illus.)—*Iron Age*, Nov. 21, 28, Dec. 5, 12, 19.

BESSEMER STEEL.

Scheibler's Modification of the Bessemer Process.—By E. Schrödter. (Produces first slag rich in phosphorous and poor in iron, and second slag rich in iron and poor in phosphorous).—*Stahl u. Eisen*, Vol. 14, p. 1097.

Johnston Steel Plant Loraine (Illustrated description).—*IronAge*, Vol. 55, p. 973.

Ohio Steel Company's Plant (General description)—*Bull. Amer. Iron and Steel Assn.*, Vol. 29, p. 115.

Steel Manufacture in Birmingham, Ala.—By C. A. Meissner (Discussion).—*Iron Age*, Vol. 55, p. 222.

Metal Mixers.—By P. Moulan (Short discussion and description).—*Revue Univ. des Mines*, Vol. 28, p. 291.

Hainsworth's Cylindrical Casting Ladle (Illustrated).—*Iron Age*, December 26th.

The Basic Blow.—By F. E. Thompson.—*Iron Age*, December 19th, 26th.

Granite City Basic Steel Works (Illustrated, descriptive).—*Iron Age*, September 5th.

Recarburizing Steel in the Basic Converter by means of Calcium Carbide.—By A. J. Rossi (German experiments).—*Iron Age*, October 2d.

Linings for Thomas Converters (Method of preparing lime or dolomite linings).—*Iron and Steel Trades Jour.*, September 21st.

The Basic Bessemer Process.—By F. E. Thompson (Extensively detailed article giving 25 tables of analysis of products at different times of blows).—*Iron Age*, August 8th.

The Thermo Chemistry of the Bessemer Process.—*Iron and Coal Trades Review*, August 23d.

Electric Hydraulic Overhead Crane (Crane built for Pennsylvania Steel Co., of Steelton; well illustrated by seven figures).—*Iron Age*, July 11th.

LEAD.

Recent American Methods and Appliances employed in the Metallurgy of Copper, Lead, Gold and Silver.—By Jos. Douglas.—*Journ. Soc. of Arts*, August 9th.

Separation and treatment of Lead Matte in the Blast Furnaces.—T. S. Austin (Showing taps and methods of separation).—*Eng. and Min. Journ.*, August 10th.

Lead Smelting in Scotland.—By A. H. Sexton.—*Eng. and Min. Journ.*, February 23d.

Improvements in Matte Smelting.—H. Lang.—*Min. and Sci. Press*, January 12.

Temperature of Gases from Lead Furnaces.—By M. W. Iles.—*S. of M. Quar.*, Vol. 17, No. 1.

On the Study of Slags from Lead Furnaces with the object of producing liquation or Crust effects.—By Jos. Struthers (Important research and extensive bibliography).—*S. and M. Quar.*, Vol. 16, No. 4.

Temperature of Lead Slags.—By M. W. Iles.—*S. and M. Quar.*, Vol. 17, No. 1.

The Manganese Slags of Tombstone, Ariz.—By John A. Church (Record of smelting the tailings from mills).—*Trans. Amer. Inst. Min. Engrs.*, Vol. 24, p. 559.

A New Slag Car for Lead and Copper Blast Furnaces.—By Carl Henrich.—*Trans. Amer. Inst. Min. Engr.*, June.

Plant for the Separation and Disposal of Slag.—By L. S. Austin (Illus. description of plant at Omaha and Grant Smelting and Refining Co., at Denver).—*Eng. and Min. Jour.*, November 23d.

Condensation of Fume by Static Electricty.—By M. W. Iles.—*S. of M. Quar.*, Vol. 16, No. 4.

Flue dust Condensers of the Freiberg Smelting Works.—By C. H. Bauer.—*Coll. Guard*, March 22d.

Brown de Camp, Fume Collector (Illustrated description).—*Eng. ana Min. Journ.*, October 19th.

COPPER.

Ten Years Progress in the Metallurgy of Copper.—By H. W. Edwards.—*Min. Journ.*, April 20th.

Stall Roasting (Extract from Peter's Seventh Edition of Metallurgy of Copper).—*Eng. and Min. Jour.*, December 14th.

A Possible Explanation of Kernal Roasting.—By H. M. Howe.—*Eng. and Min. Jour.*, February 2d.

The Anaconda Hot Air Reverberatory Furnaces, Ill. (With Sections).—*Eng. and Min. Jour.*, August 10th.

Reverberatory Furnaces in Copper Metallurgy.—By E. D. Peters, Jr. (Extracted from seventh edition of his work).—*Eng. and Min. Jour.*, August 10th, 31st.

Segregation in Ores and Mattes.—By D. H. Brown (Records of Practice at Sudbury, Conn.)—*S. of M. Quar.*, Vol. 16, No. 4.

Elimination of Impurities During the Making of "Best Selected Copper."—By Allan Gibb.—*Indust. and Iron*, May 3d.

SILVER.

Pan *vs.* Tina Amalgamation.—By Playa Blanca.—*Eng. and Min. Jour.*, December 21st.

Tina Amalgamation.—By Pazos Y. Sacio.—The Use of a Copper in place of an Iron Pan.—A short description of South American Amalgamation.—*Eng. and Min. Jour.*, September 14th.

Reduction Works of the Compania Huanchaca de Bolivia, K. F. L. (Description of Mine and Smelting Plant).—*Eng. and Min. Jour.*, December 28th.

Improved Method of Handling Pulp in Silver Mills.—By L. W. Tatum.

(Illus. Giving plan at Sheridan Mill, New Mexico).—*Eng. and Min. Jour.*, December 14th.

. Assay of Silver Sulphides.—By H. Van F. Furman.—*Trans. Amer. Inst. Min. Engrs.* June.

The "Roop" Straight Line Furnace (Illustrated), Similar to O'Hara or Brown Horse Shoe type straightened out. *Aust. Min. Stand.*, September 7th; *Eng. and Min. Journ.*, July 13th.

Lixiviation of Silver Ores at Aspen by the Russell Process.—By W. S. Morse.—*Trans. Amer. Inst. Min. Engrs.*, June.

The Stetefeldt Furnace.—By C. A. Stetefeldt.—(Description of latest form and discussion by L. D. Godschall). *Trans. Amer. Inst. Min. Engrs.*, Vol. 24, p. 1.

Product and Economical Result of the Marsac Refinery for 1892.—By C. A. Stetefeldt.—*Trans. Amer. Inst. Min. Engrs.*, Vol. 24, p. 221.

GOLD.

The Allotropism of Gold.—By H. A. Louis.—*Trans. Amer. Inst. Min. Engrs.*, Vol. 24, p. 182, 705.

Contributions to the Chemistry of the Cyanide Process.—E. A. Schneider.—*Eng. and Min. Journ.*, November 23, 30.

Chemistry of the Cyanide Process.—Is Zinc Potassium Cyanide a solvent for Gold? By J. S. C. Wells. (A record of tests).—*Eng. and Min. Journ.*

The rate of Solutions of Gold in Cyanide Solutions.—By A. W. Warwick.—*Eng. and Min. Journ.*, June, 1889.

Cyanide Patents.—By H. Bankart.—*Min. and Sci. Press*, January 5.

Cyanide Practice.—By Alfred Jones.—*Aust. Min. Stand*, July 27th.

Cyaniding or Chlorination.—By E. A. Schneider.—*Eng. and Min. Journ.*, May 18th.

Chloride of Bromine as a Gold Solvent.—By W. E. Gifford.—*Eng. and Min. Jour.*, Vol. 60. p. 27.

The Rate of Solution of Gold in Cyanide Solution.—By A. W. Warwick. (Record of experiments; results plotted in charts).—*Eng. and Min. Jour.*, Vol. 59, p. 604.

Mulholland's Bromo-Cyanide Process.—By J. S. C. Wells.—*Eng. ana Min. Jour.*, Vol. 59, p. 531.

Cyanogen Bromide and Potassium Cyanide for Dissolving Gold.—By F. A. Teed. (Discussion of Sulman's process).—*Eng. and Min. Jour.*, Vol. 59, p. 365.

Cyanide *vs.* Cyanozen Bromide.—By J. S. C. Wells. (Record of Tests).—*Eng. and Min. Jour.*, May 25th.

Notes on the Precipitation of the Precious Metals from Cyanide Solutions by Means of Zinc.—By N. Anderson.—*Proc. Col. Sci. Soc.*, April 1st.

Present Limitations of the Cyanide Process.—By C. W. Merritt.—*Trans. Amer. Inst. Min. Engrs*, June.

Dry Crushing and Cyanide.—By W. F. White—*Aust. Min. Stand.*, July 20th.

Plant for the Extraction of Gold by the Cyanide Process.—By Charles Butters and Edgar Stuart. (Abstract of Paper in Proc. Brit. Inst. Civ. Engrs. Well illustrated, giving drawings of South African plants).—*Eng. and Min. Jour.*, November 2d.

The Cyanide Process in the Witwatersrand (Transvaal) Gold Fields.—By M. Eissler.—*Sc. Amer. Sup.*, April 6th.

The Treatment of Pyritous Concentrates by Cyanide.—By A. F. Crosse.—*Min. Jour.*, May 25th, June 15th.

Cyanide Process as Applied to Concentrates from a Nova Scotia Gold Ore.—By R. W. Lodge.—*Trans. Amer. Inst. Min. Engrs.*, June.

Development of the Electric Deposition of Gold in the Transvaal.—By Emile Andriole (Condensed from "Electrical Review").—*Eng. and Min. Jour.*, December 21.

The Four-Mile Placer Fields of Colorado and Wyoming —By E. P. Snow (Well illustrated by photographic views).—*Eng. and Min. Jour.*, August 3.

The Douglas Creek Placers, Albany Co., Wyo.—By E. P. Snow (Descriptive and well illustrated by photographic reproductions).—*Eng. and Min. Jour.*, December 7.

Furnaces for Roasting Gold-Bearing Ores.—By C. G. W. Lock (Discussion).—*Jour. Soc. Arts*, March 1.

Extraction of Gold by Electrolysis.—By A. J. Rogere.—*Elec. Eng.*, June.

Refining of Gold Sulphides, Produced by the Precipitation of Gold from Chlorine and Bromine Solutions by Sulphurous Acid and Hydrogen Sulphite.—By W. Langguth.—*Trans. Amer. Inst. Min. Ergrs.*, February 9.

Melting and Refining Gold Bullion.—By H. V. Furman.—*Min. Rev.*, February 8.

Barrel Chlorination for Gold.—By A. M. Brewer.—*Tradesman*, March 1.

Improved 10-Ton Chlorination Barrel.—By J. E. Rothwell (Descriptive, with detailed drawings).—*Eng. and Min. Jour.*, October 19.

A Sand Filter for Chlorination Barrel.—By J. E. Rothwell (Ill., Descriptive).—*Eng. and Min. Jour.*; September 21.

Treatment of Roasted Gold Ores by means of Bromide.—By R. W. Lodge.—*Trans. Am. Inst. Min. Engrs.*, June.

Concentration of Auriferous Sulphides in California (3 parts. Illustrated).—*Eng. and Min. Journ.*, July 13th, November 9th and 16th.

ALUMINUM.

Production of Aluminum; its history and properties when combined with iron and steel and its special application to marine uses.—*Amer. Mech.*, September 12th.

Aluminum Bronze.—By L. Waldo.—*Trans Amer. Inst. Min. Engrs.*, Vol. 24, p. 525.

Aluminum Solders.—By J. Richards (Compositions, etc.).—*Journ. Frank. Inst.*, November.

Metallic Alloys (copper-tin; copper-zinc; copper-aluminum; chrome-zinc).—*Col. Guard*, August 2d.

Third Report Alloys Research Committee.—By W. C. Roberts-Austen.—*Iron and Coal Trades, Rev.*, May 3d.

Joseph Hall's Process for the Manufacture of Aluminum.—*Eng. and Min. Journ.*, Vol. 59, p. 581.

ELECTRO METALLURGY.

Theory of Electro-Metallurgy.—By F. B. Crocker.—*S. of M. Quar.*, January 1st.

Smelting Refractory Ores in the Electric Furnace.—By. Geo. D. Burton.—*Elec. Eng.*, September 25th.

Electro-Metallurgy as Applied to Silver Refining, etc.—By Geo. Faunce. (Lecture.)—*Jour. Frank. Inst.*, October.

ANALYTICAL CHEMISTRY.

BY E. WALLER, PH. D.

Volatilization of Salts during Evaporation. Bailey (vide QUARTERLY XV. 375.) (J. S. C. I. XIV. 1026). Further results on this subject are communicated.

Evaporations were conducted on a water bath so that no visible ebullition took place. The loss varied from 0.002 to 0.003 gramme per litre of water evaporated in the case of LiCl, to about 0.012 gramme in the case of CsCl, being apparently proportional to the molecular weight. The stronger the solutions the greater the loss.

Colorimetric for Iron. Lunge (Zts. Angew. Chem. 1896, 3). The method is only intended for very small amounts of Fe in commercial alums, etc. The method requires calibrated tubes (of proportions of small test tubes) graduated to 0.1cc., with glass stoppers; and reagents as follows: (*a*) 10 per cent. KCNS solution (*b*) pure ether (*c*) ammonia iron alum solution 8.606 gms. per litre. For use, 1cc. of this solution is diluted to 100 cc. (then 1cc.=0.00001 Fe.) The dilution will alter by standing, especially under the influence of light, so it should be freshly made up for each series of tests. (*d*) pure HNO_3. (*c*) and (*d*) should be kept away from the influence of light.

Dissolve 1 to 2 gms. of the alum to be tested in a little water, add exactly 1cc. H_2SO_4, warm, cool and dilute to 50cc. At the same time, dilute 1cc. of the HNO_3, to 50 cc., to have the same degree of acidity in both. If the sample is comparatively strong in Fe, both solutions must be diluted to the same extent with water for the same reason. Now put 5cc. of the solution of the sample in one comparison tube (A) and 5cc. of the diluted HNO_3 in other comparison tubes (B and C) and add to them an exact amount of the Fe solution (diluted (*c*) solution). Water should be added to the solution of the sample to bring the bulk as nearly as possible to the same as in the comparison tubes. Then add 5cc. of the KCNS solution to each. Now add 10 cc. of ether to each tube, stopper and shake well. Allow to stand for some hours (not so long as over night) and then compare the colors. The colors take some little time to develop completely, but the addition of the reagents should be done as nearly as possible simultaneously for the sample and the comparison cylinders.

Commercial aluminum and its alloys. Moissan (C. Rend. CXXI. 851.)

In commercial Al, a preliminary test for Cu is necessary. Dissolve in HCl, warm, pass H_2S, and keep the solution warm for some time before deciding on the presence or absence of Cu.

Si: If Cu is absent, dissolve 3 gms. in HCl, filter, fuse the residue with Na_2CO_3, dissolve in HCl, unite the solutions and evaporate to dryness for SiO_2, heating for 12 hours at 125°C. to thoroughly dehydrate. Filter, wash, etc., and weigh SiO_2.

Al: Dilute the filtrate and washings to 500 cc. Take 15 cc. for Al, neutralize with ammonia, add $(NH_4)_2S$, and digest for one hour. Wash the precipitated $Al_2(OH)_6$ repeatedly by decantation with boiling water, finally on the filter. Heat slowly up to ignition. From the weight of the precipitate deduct that of Fe_2O_3 found elsewhere.

Fe: 250 cc. Precipitate by excess of KOH, boil 10 minutes, filter, dissolve in HCl, repeat, finally dissolve in HCl, and precipitate with ammonia for weighing.

Na: Dissolve 5 gms. in hot HNO_3 (1 : 1); evaporate to dryness in a platinum dish, when dry pulverize, and then heat to just below the fusing point of $NaNO_3$ until all nitrous fumes are gone. Treat with hot water and filter. Rinse out the dish and pestle, evaporate the solution and treat as before. Three repetitions are necessary to remove all Al. Finally, convert to NaCl by evaporating with HCl, heat to 300° and then determine Na as NaCl by titration with standard $AgNO_3$.

C: Triturate 2 grammes in a mortar with 10 to 15 grammes $HgCl_2$, and a little water. The C thus set free is burned in a combustion tube, and the CO_2 caught in absorption tubes and weighed.

Cu: in the alloys is determined by dissolving in HNO_3 and electrolyzing in the usual manner. Warming will hasten the deposition.

Alumina in Phosphates. Lasne. (Bull. Soc. Chim. XV. 118.) A review of different methods. In attacking the phosphate, strong and boiling H_2SO_4 dissolves out more Al_2O_3, dilute H_2SO_4 (hot) less Al_2O_3 than is soluble in the finished product. Attack with HCl, or with aqua regia, followed by evaporation to dryness, dissolves practically the amount of Al_2O_3 which is soluble in the finished product, and which consequently is the active agent in producing "reversion."

Of methods depending (1) on the insolubility of $(FeAl)_2(PO_4)_2$ in dilute acetic, two are criticised. The acetic method (vid Wyatt, Phosphates of America) and the ammonium acetate method of Crispo (essentially similar to that described by Smethan, (vid. QUARTERLY XIV. 255), except that after obtaining a solution of $(FeAl)_2(PO_4)_2$, the P_2O_5 is separated by molybdate, and from the filtrate $Al_2(OH)_6$ and $Fe_2(OH)_6$ are precipitated by ammonia.) The acetic method affords an incomplete precipitation of Al_2O_3, and always some lime, so that by a compensation of errors, it may at times give, by chance, correct results. Crispo's method, conducted as he describes it, affords a precipitate containing MoO_3. When this is removed, the results are too low. The imperfections of the method are not as great as with the acetic method.

Of methods depending (2) on the preliminary separation of P_2O_5, the use of Sn or Bi affords no satisfactory or constant result. That with MoO_3 is exceedingly tedious, if any approach to accuracy is obtained. That by Mg in ammoniacal citrate solution is uncertain; too much or too little Mg or citrate will either leave bases in the solution to be counted as Al_2O_3, or will fail to bring down all the P_2O_5.

Of methods depending (3) on the preliminary separation of CaO, the Glaser method is condemned, because it leaves in the solution MgO and MnO, to masquerade as Al_2O_3, and is therefore incorrect. Ferd. Jean's method—separating Ca as $CaSO_4$ by alcohol, and then removing P_2O_5 by Mg in ammoniacal citrate, is long and inaccurate.

The oxalic method, in which the lime is separated as oxalate, and in the filtrate the other bases are separated as phosphates, and after filtration the P_2O_5 is separated by MoO_3 may be made accurate, but is too tedious for ordinary work. By certain modifications which are minutely described, the method can be made more convenient and very accurate, but it is still too cumbersome for commercial work.

The method recommended depends upon the fact that that Al_2O_3 is soluble in NaOH in presence of an excess of phosphate, whereas other bases are made insoluble either as hydrates or phosphates. 1.25 gramme of the sample is evaporated to dryness with HCl to remove HF and render SiO_2 insoluble. Take up with water and filter. Run the solution into a nickel dish containing a solution of 5 gms. C. P. NaOH and 1 gm. Na_2HPO_4. Warm for about an hour to 100° with stirring. Decant into a 250 cc. flask, cool, and fill to the mark with 0.5cc. additional to allow for the bulk of the precipitate. Filter off 200cc. (representing 1 gm) acidify, add NH_4Cl and slight excess of ammonia, boil to precipitate $Al_2(PO_4)_2$. Filter off, dissolve in HCl (1:20) with warming, then add 3.5cc. of a 10 per cent. solution of $(NH_4)_2HPO_4$ nearly neutralize with ammonia, dilute to 250cc. and add 1.5 gm $(NH_4)_2S_2O_8$. Boil half an hour, then add 5 drops concent. solution of $NH_4C_2H_3O_2$, boil 10 minutes longer, filter, wash and ignite $Al_2(PO_4)_2$. The weight of the precipitate multiplied by 0.418 gives Al_2O_3. To this add 0.0008 grm to compensate for solubility.

Chrome Iron ore, Ferrochromium, etc. Rideal and Rosemblum (Chem. News LXXIII. 1, also, J. S. C. I. XIV. 1017). If the ore, or ferro-chromium is in very fine powder, heating for five minutes with Na_2O_2 will effect conversion to chromate. It is, however, advisable to add a second quantity of Na_2O_2 after the melt has partially cooled, and to heat again. After dissolving, the solution should be boiled 10 minutes before acidulating to decompose any Na_2O_2 which may remain. Before titrating, the solution had best be filtered to avoid possible interference with the obtaining of the end reaction.

A bibliography of the subject is given in the paper. For ores use 0.5 gm. and 3 gms. Na_2O_2, heat in Ni crucible for 5 minutes after the mass is fluid, cool to a crust, add 1 gm. Na_2O_2 and heat 5 minutes more. Leach out with water, filter, boil 10 minutes acidify with H_2SO_4 and titrate.

Manganese determination. Reddrop and Ramage (J. Lond. Chem. Soc. LXVII. 268). A method on the principle of Deshays' method. Dissolve a known amount of the iron, steel or alloy in HNO_3 (1:3), add sodium bismuthate cold to an aliquot portion of the solution, stir, filter and titrate immediately with H_2O_2. The sodium bismuthate should be free from Cl. It is made by fusing together 10 parts "subnitrate of bismuth," 20 parts NaOH and 2 parts Na_2O_2. After fusion, wash out soluble salts, pulverize and dry. The method is asserted to be the most rapid of any.

Manganese in irons and steels (volumetric). Auchy (J. Am. Chem. Soc.,

XVII., 943). Williams' method ($KClO_3$, etc.) is the one most generally used in our iron and steel laboratories. The author finds that it does not invariably give constant or trustworthy results. Deshays' method (oxidizing with PbO_2, and titrating with As_2O_3), he finds, gives uniformly low results. The Volhard method (ZnO and titration with $K_2Mn_2O_8$) is regarded as the most satisfactory. Certain precautions (which are detailed) must be observed, as well as uniformity of procedure. The mode of conducting the analysis is given as follows: In a 6-inch evaporating dish, treat 3.3 gms. with 40 cc. HNO_3 (1:1 or a little stronger); add 8cc. (*no more*) of conc. H_2SO_4. Heat covered. If the liquid becomes cloudy on boiling, bumping and spattering will occur later on. To avoid this, add some strong HCl and boil down rapidly until the mass is *nearly* dry—only a little pastiness here and there; cool for a minute or two; take up with *hot* water; boil a few minutes; cool by standing in cold water; pour into a 500cc. flask; *nearly neutralize* with Na_2CO_3; add ZnO emulsion until sudden "stiffening" of the solution occurs; dilute to the mark; empty into a beaker; mix with a rod—filter off rapidly 250cc. Transfer this solution to a 500cc. Erlenmeyer flask; heat to boiling; add nearly the full amount of $K_2Mn_2O_8$ solution of strength exactly (1cc= 0.0055 Mn) if the percentage is approximately known. If not, add 1.5 cc. and boil until the MnO_2 separates in flakes and the liquid becomes yellow. Finish the titration, shaking after each addition *until the yellow reappears*. The pink end-reaction should persist after shaking several times. The number of cc. of $K_2Mn_2O_8$ used, divided by 10, gives per cent. Mn.

The italicized words in this description call attention to the precautions regarded as especially essential.

Common "sal soda" may be used for neutralizing, but in that case a correction for the Mn therein must be determined. It is likely to amount to about 0.03 per cent. in the result.

Pure Zinc. Funk. (Ber. XXVIII. 3129.) By the use of Fisher's reagent—para-amido-dimethyl-anilin in HCl solutions, followed by Fe_2Cl_6 solution, H_2S was easily detected in the gases evolved on dissolving the samples (blue coloration). C was detected and determined by mixing the metal with $KClO_3$ and burning in a tube, the gases being passed through dilute solution of basic lead acetate. None of the samples obtained were absolutely free from S or C. Neither element, however, dissolves in the Zn, and by fusing and filtering (through asbestos) they could be removed.

Volumetric determination of Zinc. Lescoeur and Lemaire. (Bull. Soc. Chim. XIII. 880.) Adding decinormal $Ba(OH)_2$ solution to an acid solution of Zn until methyl orange indicator shows neutrality, brings the liquid into a state where introduction of phenol phthalein, and titration to neutrality for that indicator, gives the measure of the Zn. The solution must, however, be quite dilute, or the precipitate of $Zn(OH)_2$ will enclose portions of the material, and give erroneous results. This fact, the authors believe, has caused M. Barthe to criticize their method adversely, and to assert that a basic salt of Zn is partially precipitated by their method of manipulation.

Nickel and Cobalt. Carnot. (Ann. des Mines, VIII. 624.) The metals are precipitated together by KOH and Br. The oxides are reduced to metal by heating in a current of H, and weighed together.

They are then dissolved in HNO_3, and the solution divided in halves. In one half, KOH and H_2O_2 are added, which gives $Ni(OH)_2$ and $Co_2(OH)_6$. On acidifying and adding KI, I corresponding to the Co_2O_3 is set free. which is titrated with standard $Na_2S_2O_3$. The other half is neutralized with KOH, KCy added to just redissolve the precipitate, then Br. This precipitates $Ni_2(OH)_6$ which can be titrated by KI and standard $Na_2S_2O_3$ in the same manner.

Technical Analysis of Lead. Nissenson and Neumann. (Chem. Ztg. XIX. 1141.) In "soft lead" As and Mn rarely occur. For the determination of the other metals, electrolytic methods are used as much as possible. 200 grammes of the metal are treated with 1275 cc. of water and 325 cc. strong HNO_3. After solution, 62 cc. conc. H_2SO_4 are added with shaking, after cooling the solution is made up to 2000 cc., well shaken, and the $PbSO_4$ filtered off. This occupies a bulk of 46 cc., for which allowance must be made in calculating results. Some Sb is carried down with the $PbSO_4$ which is recovered by dissolving in NaOH, adding 25 cc. of cold saturated Na_2S solution and filtering. This solution is united with that obtained by digesting with Na_2S the H_2S precipitate from the concentrated filtrate from $PbSO_4$. From the Na_2S solution boiling hot the Sb is separated by electrolysis ($ND_{100} = 1.2$) in half an hour, and, after adding 25 gms. $(NH_4)_2SO_4$. Sn may be separated under the same conditions in 20 minutes. If As is present the sulphides must be separated, treated with $(NH_4)_2CO_3$ to dissolve out As, and then treated as above.

The sulphides of other H_2S metals are dissolved in aqua regia, AgCl filtered off Bi separated by $(NH_4)_2CO_3$, and Cd by adding KCy and Na_2S. Or an electrolytic separation may be used. Cu may be obtained electrolytically after destroying KCy, etc., by evaporation with H_2SO_4.

The filtrate from the H_2S group treated as usual, Ni and Co being determined by electrolysis of ammoniacal solution after separating their oxides by Br water and NaOH, and separating Fe from their oxides by ammonia. Fe is titrated by permanganate, Zn by standard Na_2S, Ag is determined by cupellation, Pb by difference.

In "Hard Lead" Sb is usually the only determination required. The proportions used are: 2.5 grms. of the sample, 10 grms. $H_2C_4H_4O_6$, 15 cc. H_2O, and 4cc. HNO_3. After solution add 4 cc. conc. H_2SO_4, dilute to 250 cc. Let settle, draw off 50 cc., add NaOH, then Na_2S, filter, and electrolyze for Sb.

For "Work lead" (Werkblei) the treatment is essentially similar to that for "Soft Lead" except that $H_2C_4H_4O_6$ is used in dissolving the sample (10 to 50 gms. used.)

In Galenas Ag is determined by fire assay and cupellation. Pb by fire assay, or sometimes by electrolysis (Hot HNO_3 solution $ND_{100}=1$), in an hour. Separation as PbO_2 on the anode.

As is determined by precipitation as $MgNH_4AsO_4$ in a solution containing NH_4 salts and $H_2C_4H_4O_6$.

Zn by dissolving in HCl, boiling out H_2S, adding HNO_3 and H_2SO_4 evaporating down, separating Fe, etc., by ammonia, and in the filtrate titrating with standard Na_2S.

Volumetric for Lead. Beebe. (*Eng and Min. Jour.*) The test solution contains 11 gms. K_4FeCy_6 per litre. The end reaction is obtained

by "spotting" a drop of the (acetate) solution on a white plate in contact with a drop of $UO_2(C_2H_3O_2)_2$ solution containing a little free acetic. The ore is treated with HNO_3, aided, if necessary, by a little HCl, then Pb is converted to sulphate by evaporating with H_2SO_4 to fumes, whereupon the solution is diluted, filtered and precipitate well washed. Convert Pb to carbonate by digestion with alkaline carbonate, which is then dissolved in $HC_2H_3O_2$ and titrated. The spot test shows a pinkish tinge changing slowly to brown, when an excess of K_4FeCy_6 has been added.

Methods for separation of Bismuth and Lead. Stein. (Zts. Angew. Chem., 1895. 530.) A comparison of twelve different methods. Only three proved fairly satisfactory in the author's hands. These were:

Rose's method, adding HCl to the dilute HNO_3 solution until a few drops give no turbidity on dilution with an equal bulk of water. Pb is then precipitated by H_2SO_4 with addition of alcohol, and in the filtrate the Bi is precipitated by ammonia.

Lowe's method. The nitrate solution is repeatedly evaporated with water until water gives no white clouding when added to the evaporated mass. Then a cold dilute solution of NH_4NO_3 is added to the residue, and after digesting to dissolve $Pb(NO_3)_2$, $Bi(OH)_2NO_3$ is left behind. In the filtrate Pb may be separated as PbS or $PbSO_4$.

Jannasch's method. Passing Br over the mixed sulphides of the metals. On heating $BiBr_3$ can be easily volatilized off leaving $PbBr_2$ behind.

Mercury in Cinnabars. Rising and Lehner. (J. Am. Chem. Soc, XVIII. 96). The Hg is readily dissolved out by HBr. The acid can be easily made by distilling KBr with H_2SO_4 of 56° Bé and conducting the distillate into water.

A dilution containing a little over 12 per cent. HBr was found to be effective. After dissolving out the Hg, and filtering, the solution is to be nearly neutralized with KOH, and KCy added in sufficient excess to dissolve the precipitate first formed. Then by electrolyzing with a weak current in a platinum dish, the whole of the Hg can be obtained for weighing.

Mercury in Cinnabar. Smith and Wallace. (J. Am. Chem. Soc., XVIII. 169.) 0.2 to 0.25 gramme of the pulverized mineral is weighed out, and digested in 20 to 25cc. of Na_2S solution (Sp. Gr. 1.22) until the Hg is dissolved. The solution is then diluted (filtering not specified) to about 125cc., and subjected to electrolysis with a current of $ND_{100}=$ 0.12 to 0.13 ampere, in a platinum dish at a temperature of 70°C. In the course of 3 hours or less, all of the Hg will have been deposited, when it can be washed, dried and weighed. The dish should be covered to prevent evaporation, otherwise a ring of Hg, partially converted into HgS will be perceived near the top of the deposit. Check analyses against the longer process (weighing as HgS) show accurate results by this method.

Separation of Arsenic, Antimony and Tin. Kassner. (Fres. Zts. Anal. Chem. XXXIV. 596).

The freshly precipitated sulphides suspended in water, are treated with Na_2O_2 which immediately converts them to arsenate, antimonate and stannate. By acidifying metastannic acid may be separated, and in the filtrate by boiling down and adding alcohol, $Na_2H_2Sb_2O_7$ can be separated.

Separation of Arsenic. Friedheim and Michaelis. (Ber. XXVIII. 1414).

Fischer's distillation method or its modifications introduces so much iron into the solution that if a subsequent determination of Ni, W, Vd, etc., is required, much difficulty is experienced. The authors find that As_2O_5 with HCl and methyl alcohol, will distil over, probably as an arsenious ester, which is decomposable by water. With a specially constructed apparatus, the operation may be readily conducted, 50 cc of methyl alcohol being added to the solution tested, and the operation being conducted by aid of a current of HCl gas. The more the methyl alcohol is diluted by the water of the solution, the greater the number of repetitions of the distillation required. The separation from W, Vd or Mo by this method was found to be very satisfactory.

Arsenious Acid and Chromates. Tarugi. (Gazz. Chim. XXV. 248.) As_2O_3 and CrO_3, when simultaneously present in the same solution will, on boiling with alkali, slowly form $Cr_2(AsO_4)_2$. If the heating is only for a short time, either or both of these compounds may be detected in the solution.

Antimony. Precipitation by hydrogen sulphide. Bosek. (J. Lond. Chem. Soc. LXVII. 515.) It was found difficult to obtain solutions containing only pentad Sb. Heating the metal with Br water at 100° for 12 hours gave the only satisfactory result. The precipitate with H_2S is usually a mixture of Sb_2S_3 and Sb_2S_5. Heat and slow passage of the gas, also a larger proportion of HCl, increased the proportion of Sb_2S_3, and vice versa for obtaining Sb_2S_5. Hot precipitation in presence of $K_2Cr_2O_7$ affords a crystalline brown violet Sb_2S_4, easily converted to black Sb_2S_3. Evaporating solutions of $SbCl_3$ with $KClO_3$ affords double salts. Of these, $3KCl.2SbCl_3$ affords with H_2S, the violet Sb_2S_4.

Delicate reaction for Tin. Deniges (Rev. Int. des Falsif. VIII. 98). A solution of brucine in HNO_3 affords a reddish violet coloration with stannous salts. The reaction occurs whether Cu or Fe are present or not. The reagent is made up by dissolving 0.5 gramme brucine in 5cc. HNO_3 in the cold, adding 250 cc. of water, boiling for 10 or 15 minutes, and making up the volume to 250 cc. A little of the substance is acidified with HCl, evaporated to dryness the residue dissolved in a few drops of water, and (at most) 1cc. of the cold brucine solution added.

To detect metastannic acid, add to the sample 1cc. H_2O, 0.5cc. HCl and a fragment of pure Zn. The Sn is deposited on the Zn and may then be detected by the procedure described.

This is essentially a reversal of the brucine stannous chloride test for HNO_3, described in some of the works on qualitative analysis (Abs).

Determining Tin on tinned iron. Lunge (Zts. Angew. Chem. 1895, 429). The material, cut into strips, is subjected in an ignition tube, to the action of *dry* Cl gas. If only a gentle heat is used, no Fe_2Cl_6 is volatilized with the $SnCl_4$. At first the action of the Cl raises the temperature sufficiently—later on a gentle heat is applied. The $SnCl_4$ is caught in water in two Peligot bulb tubs, an Erlenmeyer wash bottle being put at the end of the train.

Platinum metals in Assays of Gold. Priwasnik (Oesterr. Zts. Berg. u. Huttenwesen, XLIII. 272). The presence of Pt or metals of that group usually shows in the rough or crystalline surface of the buttons at the

end of the cupellation. Such buttons on melting up with Ag, and parting in the usual manner give cornets apparently of pure gold, so long as they contain under 9 per cent. of Pt. If but 2 per cent. of Pt is present, dissolving off the Ag by means of HNO_3 removes it, but the H_2SO_4 method does not. Chandet's suggestion, repeated inquartation (with Ag and HNO_3) until the weight of the cornets remains essentially the same, seems to be good. If the solution shows any color, Pd must be present, as the PtAg compound gives a colorless solution. Ir may be settled out by keeping the ingot molten for sometime.

No means of avoiding errors due to the presence of Rh are as yet known. Very small proportions of Ru will cause the buttons to "sprout" in a very decided manner. The buttons always have a characteristic dull appearance. Os being comparative easily oxidized to volatile forms causes no difficulties.

Chloroplatinates. Determination of potassium, ammonium, nitrogen or platinum. Methods based on the determination of the Cl in K_2PtCl_4 or $(NH_4)_2$ $PtCl_4$ have been proposed by different analysts. Mohr. (Fres. Zts. Anal. Chem. XII. 137), reduced by ignition with $Na_2C_2O_4$. De Koninck (ib. XXI. 406), dissolved in hot water and reduced with a strip of Mg ribbon. He afterward used (as being preferable) Mg powder. It is found, however, that the Mg obtainable, almost always contains some Cl. Dubernard (ib. XXV. 551) used metallic Zn in the same manner. Corenwinder and Contamine (C. Rend. LXXXIX. 907), reduced by heating with a formiate. Hinz. (Fres. Zts Anal. Chem. LIII. 72) finds that $Ca(CHO_2)_2$ is the best salt to use. After washing with alcohol, dissolve in hot water, add the $Ca(CHO_2)_2$ and warm for some time—until the Pt settles completely. Neutralize with pure $CaCO_3$ (prepared from $Ca(NO_3)_2$ and $Na_2[CO_3]$ filter and wash, and in the filtrate titrate the Cl by standard $AgNO_3$.

Electrolytic Separation of Manganese and Tin. (Ber. XXVIII. 3182). In working with the roughened platinum dishes recommended by Classen, it was found that Mn is not rapidly separated as MnO_2, nor is the deposit adherent. The addition of chrome alum in $NH_4C_2H_3O_2$ solution was found to remove these difficulties. The Mn salt (sulphate not chloride) was dissolved in about 50 cc. of water, and 10 grammes $NH_4C_2H_3O_2$ and 1.5 to 2 grammes chrome alum added. On diluting to 150 cc. and warming to 80°C, with a current $ND_{100} = 0.6$ to 1 ampere (tension 3 to 4 volts) rapid deposition of an adherent coat was obtained. The first results obtained were somewhat high from retention of small amounts of CrO_3. This was easily removed by igniting, then washing thoroughly with water and alcohol, and then drying off by holding the dish for a moment in the blast flame. The ignition should be carried to the formation of Mn_3O_4 for weighing, the change being easily observed by the change of color to a reddish brown.

Tin in presence of hydroxylamine sulphate, is prevented from yielding stannic acid. The addition of 0.2 to 0.3 gramme of that reagent gives satisfactory results. Hydroxylamine chloride was less favorable. $HC_2H_3O_2$, $(NH_4)C_2H_3O_2$ or $H_2C_4H_4O_6$ favor the progress of the deposition, whether used separately or together. Working at a temperature of 60°C with a current $ND_{100} = 0.8$ amp. the complete precipitation of 0.3 to 0.34 gramme Sn can be effected in 3 hours.

Pure Glucina from Emerald. Lebeau (C. Rend. CXXI. 641). The

emerald is fused with twice its weight of CaF_2 in a crucible. When fluid, the melt is slowly poured into a mass of water. The material is then pulverized and treated cold with H_2SO_4. When SiF_4 ceases to come off the material is heated until it evolves strong fumes. This is then thrown into water in small portions at a time, $CaSO_4$ deposits, and the G, etc., remain in solution as sulphates. Decant, wash the precipitate and concentrate the solution.

Partial saturation with K_2CO_3 and cooling, allows the removal of much Al as alum. In the mother liquors, NH_3 and $(NH_4)_2CO_3$ in excess, on standing for some days with frequent stirring, precipitates more impurity, and then boiling the filtrate affords an impure precipitate containing G. Dissolve in HNO_3, and add a little K_4FeCy_6 to separate Fe, filter, remove excess of K_4FeCy_6 by means of $Cu(NO_3)_2$, and separate excess of Cu by H_2S. In the absence of Fe the G is precipitable by ammonia. Add ammonia in excess—allow to stand for some days that the $Al_2(OH)_6$ may pass into the more insoluble form. Then on decanting off the supernatant liquid, and digesting with $(NH_4)_2CO_3$, the G compound is dissolved, and from the solution pure $G(OH)_2$ may be precipitated by boiling. Dissolving in HNO_3, evaporating and igniting, affords pure GO.

Determining Molybdenum. Friedheim and Euler. (Ber. XXVIII. 2061). The method by heating at 440° in a stream of dry HCl gas—by which means Debrays' salt, $MoO(OH)_2Cl_2$, is volatilized, which, in contact with water, is converted to MoO_3 and HCl, is inapplicable in the examination of ammonium molybdates and of certain metals, the chlorides of which are volatile. Milch, Rose, Finkener and others separate MoS_2 and roast carefully to MoO_3 for weighing. This requires very careful manipulation to avoid reduction of some Mo. Von der Pfordten prefers to reduce completely to metal for weighing.

Of volumetric methods, Pisani and Von der Pfordten applied reduction with Zn and titration with $K_2Mn_2O_8$, applicable only for small amounts. Seubert and Pollard's method of acidimetric titration is only suitable in the case of alkaline molybdates, and also Schindler's method—titration with Pb $(C_2H_3O_2)_2$, using tannin as an indicator, is of limited service. The method of Mauro and Danesi (Fres Zts Anal. Chem., XX. 507) is, however, generally applicable. This consists in adding HI (or KI and HCl) and heating for some hours. The reaction is either $MoO_3+2HI=MoO_2I+I+H_2O$ or $2MoO_3+2HI=Mo_2O_5+I_2+H_2O$. In either case one atom of I is set free for each molecule of MoO_3. The I is caught in KI and titrated with $Na_2S_2O_3$.

Determination of Argon. Schloesing (C. Rend. CXXI. 525.) The gas volume is measured, after eliminating O and CO_2 the N being removed by passing it over incandescent Mg. The proportion of argon in atmospheric air was found to be 0.935 vols. in 100.

Separating Argon from Nitrogen. Linb. (C. Rend. CXXI. 887.) BaF or 2 NaF, BaF_2 on heating with metallic Na, affords a gray substance (no doubt chiefly reduced Ba) which absorbs N with great readiness. The author has not determined whether it absorbs argon, but it presumably does not. Metallic Li, which has been proposed for this purpose is too expensive. Deslandres (ib. December, 1895) found that the Li which he used afforded H on heating, and required to be heated for some time in vacuo before it could be used. The surface of Li when fresh absorbs N in the cold, but it soon becomes covered with a blackish film, which stops the action.

Color Reaction for Chlorate. Deniges. (J. Pharm. Chem. [6] II. 400.) The resorcinol reagent for nitrites, (1 gm. in 10 drops H_2SO_4 diluted to 100 cc.) can also be used for chlorates. The chlorate solution should not contain over 2 per cent. of the same.

Mix a little H_2SO_4 with the solution, cool, shake well, add 5 drops of the resorcinol reagent, immerse in cold water for a short time, then shake. A green color will develop if chlorate is present. 0.0001 gm. may be thus detected.

Quantitative for Perchlorate. Kreider. (Am. J. Sci. L. Oct. 1895). Heating $KClO_4$ with meta phosphoric acid (HPO_3) at 200°C., in presence of KI, causes copious evolution of I. This reaction, applied for analysis of $KClO_4$, gave erroneous (high) results. Mixture of the $KClO_4$ with $ZnCl_2$ and treating with HPO_3 as above, also gave high results. Fusion of $KClO_4$ with $Al_2Cl_6.2NaCl$ gave copious evolution of Cl in presence of air, but none in an atmosphere of CO_2. Mixing these with KI gave evolution of I, but the results were low. Addition of $MnCl_2$, $ZnCl_2$, etc., did not help the matter. The method finally found to be most satisfactory was: collection of the O of the perchlorate; its subsequent passage into an atmosphere of NO over a strong solution of HI, and the titration of the I thus liberated with decinormal As_2O_3 in alkaline solution. For description of the apparatus the original paper must be consulted.

Separation of Bromine and Chlorine. Bugarsky. (Zts. Anorg. Chem. X. 387). Place a measured volume of the solution containing bromide and chloride in a half litre Erlenmeyer flask, add 50 cc. (or more if much Br is present) of tenth normal biniodate, (3.249 gms. $KH(IO_3)_2$ per litre), then 10 cc. of H_2SO_4 (20 per cent. by volume) and water to make up to 200 cc. Then add a pinch of powdered pumice stone. Place the flask on a wire gauze over a lamp. Boil until the bulk of the liquid is reduced to 60 to 80 cc. Cool the contents of the flask, rinse into a 100 cc. flask, and divide in halves. In one-half add a crystal of KI and titrate the I which separates by standard $Na_2S_2O_3$, thereby obtaining a basis for the calculation of the amount of iodate which has been decomposed, and per contra the Br present, in the other half determine HCl by Volhard's method (NH_4CyS) after reducing iodate with 5 to 10 cc. of 2 per cent. SO_2 solution, adding 2 to 5 cc. of a 7 per cent. solution of $NaNO_2$, and boiling 5 to 8 minutes to expel I.

Iodine in Sea weed ashes. Otto Jensen (Chem. Ztg. Rep. 1895, 371). Duflos process. Setting free by $Fe_2(SO_4)_3$ and distilling over I, is comparatively rapid, but the last traces of I are driven over with difficulty. Lasseique's method. Precipitation as PdI_2 requires rather delicate manipulation. Gröger's method is slow but accurate. (vid QUARTERLY XV. 279.)

Fluorine in Mineral Waters. Casares. (Fres. Zts. Anal. Chem. XXXIV. 546). In some sulphur waters from Spain, F was found to be present. It was quantitatively determined by adding Na_2CO_3, evaporating to small bulk, then precipitating hot with $CaCl_2$, washing and igniting the precipitate, treating it then with $HC_2H_3O_2$ to remove carbonates, and filtering off and igniting the residue. This material was analyzed by two different methods, Fresenius' (vid. Quant. Anal.) absorbing and weighing H_2SiF_4; and Carnot's (vid. QUARTERLY XIII. 385, also XIV. 258), weighing K_2SiF_4. The latter gave low results in some

cases, but t .e results in all agreed fairly well. The plan in both methods consists in mixing the material intimately with finely pulverized quartz, and treating in a small flask with H_2SO_4, containing no water, passing a current of dry air through the apparatus, and purifying the escaping gases, with dry $CaCl_2$ and pumice (soaked in $CuSO_4$ and afterward dehydrated.) Fresenius absorbs the SiF_4 in soda lime. Carnot passes it (under Hg) into a 10 per cent. solution of KCl, filters off and weighs K_2SiF_6).

Determination of Boric acid. Jay and Dupasquier. (Bull. Soc. Chem. XIII. 877.) The material, dry, and free from organic matter, is treated with 25 to 30 cc. of methyl alcohol and HCl or H_2SO_4 and distilled off, the distillate being caught in standard alkali. The apparatus consists of two flasks of about 200 cc. capacity. The generating flask carries above it an inverted condenser, the tube of which reaches nearly to the bottom of the flask where it is recurved. A side tube from this condenser tube connects also with the receiving flask. Another tube connects the two flasks directly, delivering near the bottom. The receiving flask is charged with enough caustic alkali solution to retain all the BoO_3. At the start the generating flask is heated a little more highly than the receiving flask, but when the methyl alcohol is at a full boil, both are heated to about the same extent. By this arrangement the methyl alcohol is used over and over. In the course of at most 1½ hours 0.3 gm. B_2O_3 can thus be driven over and fixed by the alkali.

The liquid is gently warmed to expel methyl alcohol, then rendered slightly acid with a few drops of dilute HCl, warmed again to expel traces of CO_2 cooled to 15 or 20°, and a decime solution of NaOH run in until a drop on sensitive litmus paper shows neutrality. Then add 2 drops of a water solution of C.L.B. blue (10 gms. per litre) and titrate until the first change of tint is noted. This last gives the measure of the B_2O_3. Some practice is necessary to recognize the end point. Also a correction of 0.2 to 0.3 cc. of the alkali (according to the volume of the solution titrated) will be necessary. HF if present increases the apparent amount of B_2O_3.

Silicon in Iron. Liebrich. (Stahl u. Eisen, XV. 1058.) After separating SiO_2 in the usual manner, the graphite which remains with it can be removed by fusing with a little $KHSO_4$. On dissolving off the sulphate, the SiO_2 is left perfectly clean and white.

Separation of Quartz. Michaelis. (Chem. Ztg. XIX. 1422.) A 10 per cent. NaOH solution does not attack quartz on boiling, and may be used to separate soluble SiO_2 in analysis of clays, etc. Results which have seemed to indicate such an attack of SiO_2, are attributable to the passage of the finely divided quartz through the filter. Lunge (Zts. Angew. Chem. 1895, 563 and 689) finds that there is less tendency to loss of this kind when Na_2CO_3 is used, while in its solvent action it is quite as efficient. He therefore expresses preference for the use of Na_2CO_3 solution.

Carbon in Iron. Volhier (Stahl u. Eisen XV. 199). Peipers, an engineer, has proposed a method consisting of marking with the steel on a "streak plate" of unglazed porcelain, treating the streak with $2NH_4Cl,CuCl_2$ solution, and comparing with "streaks" similarly treated from irons containing known amounts of C. Differences of 0.05 or even of 0.025 per cent. are stated to be perceptible in this method.

Carbon in Tungsten Steels, etc. Foerster (Zts. Anorg. Chem. VIII.). With some wrought irons and with tungsten steels, the treatment with $CuCl_2,2NH_4Cl$ gives a tumultuous escape of gaseous hydrocarbons. If the samples are first treated with a mixture of 10 per cent. $CuSO_4$ added to saturated $(N_2H_4)_2C_2O_4$ at 80° for five hours, and afterward with the chloride solution to dissolve the Cu, this difficulty is avoided.

Determination of Carbon dioxide. Gooch and Phelps (Am. Jour. Sci. L. August, 1895). The CO_2 is set free in a flask by the means employed in the Scheibler method. Upsetting a small test tube containing HCl on to the substance, after weighing out and closing the flask. The evolved gas is passed through a tube with a bulb blown on it, through a valve in $Ba(OH)_2$ solution. The $Ba(OH)_2$ solution is contained in a vessel, the bottom of which consists of a rubber balloon to allow for expansion. After the CO_2 has been entirely driven into the solution by boiling, the $BaCO_3$ is filtered off, converted to $BaSO_4$ and weighed as such. A saturated of $Ba(OH)_2$ contains about 5 per cent. of the hydrate, and it is advisable to use an amount "at least a fourth in excess of the quantity theoretically required."

Phosphate determination. Neubauer (Zts. Anorg. Chem. X. 60). A comparison of results by the methods of Fresenius, Märcker, Wagner and the author, are given and critically discussed. The method of the author (vid. QUARTERLY XV. 156) is restated with some additions. To avoid loss by volatilization of P_2O_5 on igniting, the crucible cover should have a layer of MgO on its underside. Ignition should be maintained for at least an hour over a strong burner. The *whole crucible* must be in full glow during ignition. Care must be taken that the MgO lined cover does not by itself increase in weight in the flame. Gas containing much S should not be used for the purpose of heating. It is better to use instead a suitably arranged spirit lamp.

Phosphorus in Titaniferous Ores. Hogg (J. S. C. I. XIV. 1022.) In experiments on this subject, when the conditions were such that all P_2O_5 was completely separable as phosphomolybdate in 30 minutes if TiO_2 was absent, four hours were required for complete separation when TiO_2 was present.

Precipitating Phosphomolybdate in Steel analysis. Auchy. (J. Am. Chem. Soc. XVIII. 170.) A larger bulk of solution, and considerable amount of NH_4NO_3 facilitate the complete precipitation of the phosphomolybdate. The use of old molybdate solution, from which some of the MoO_3 has separated by standing, may cause unexpected errors. The exact regulation of the temperature at which the precipitation should be effected does not appear to the author to be so important as many imagine.

Warning is given of the presence of P, in some very clean looking $FeSO_4$ labelled "Free from phosphorus" and also of the same element in some HNO_3 labelled C.P.

Phosphomolybdate. Gladding. (J. Am. Chem. Soc. XVIII. 23.) An analysis of the "yellow precipitate," showed after drying at 105° C.

48 MO_3	91.36
2 P_2O_5	3.76
10 NH_3	2.31
11 H_2O	2.57

The formula for the crystallized salt is: $24\ MoO_3.P_2O_5\ 3(NH_4)_2O. + 24MoO_3P_2O_5\ 2(NH_4)_2O.H_2O. + 5aq.$

Drying and weighing the precipitate has hitherto been regarded as applicable only when very small proportions of P_2O_5 were present, but by proper management it can be used for the determination of higher proportions of P_2O_5 (fertilizers, etc.). To the P_2O_5 solution (25 to 50 cc.) add 25 cc. strong ammonia (Sp. Gr. 0.9). Then acidify with HNO_3 (Sp Gr. 1.42). Place in a water bath at 50° C., and add MoO_3 solution from a burette at the rate of about 3 drops per second, with constant stirring. When molybdate to an excess of about 10 cc. has been added, allow to remain for 10 minutes in the bath. Filter through a weighed filter, wash with 1 per cent. HNO_3, dry at 105° C and weigh.

Phosphorus in Steel. Blair (Trans. Am. Inst. M. Eng.) gives a review of the results recorded in Thackray's paper (QUARTERLY XVII. 199) essentially as follows: Twenty-seven methods used falling under two heads, viz.:

1. Acetate method (A) (called "citric acid method" by some.
2. Molybdate method.

The latter is subdivided into five methods, viz.:

Titrating the reduced MoO_3 after passing through reductor. (B).
Titrating reduced MoO_3 after boiling with Zn and filtering. (C).
Weighing the "yellow precipitate." (D).
Redissolving "yellow precipitate" in ammonia and precipitating by Mg mixture, and weighing $Mg_2P_2O_7$. (E).
Acidimetric titration of the yellow precipitate. (F).

The results arranged under these different methods were:

	Method A.		Method B.		Method C.		Method D.	
	No. 1	No. 2	No. 1	No. 2	No. 1	No. 2	No. 1	No. 2
Number of results, . .	3	3	3	3	2	2	6	6
Highest per cent., . .	0.049	0.081	0.0515	0.0835	0.049	0.083	0.052	0.086
Lowest per cent., . .	0.046	0.078	0.0495	0.0816	0.045	0.080	0.049	0.083
Average per cent., . .	0.048	0.080	0.050	0.083	0.047	0.082	0.050	0.084

	Method E.		Method F.	
	No. 1	No. 2	No. 1	No. 2
Number of results, . .	11	11	4	4
Highest per cent., . .	0.055	0.089	0.053	0.086
Lowest per cent., . .	0.046	0.076	0.046	0.078
Average per cent., . .	0.049	0.083	0.049	0.081

The greatest variation is under method E, which might naturally be expected.

Averages of all the results, No. 1, 0.049; No. 2, 0.082.

Determining Phosphoric Acid by acidimetric titration of the yellow precipitate. Kilgore. (J. Am. Chem. Soc. XVII. 950.) Vid. QUARTERLY XVI. 179. An account of results by several different chemists using the author's modification (precipitation at 60°C) and experiments in connection with the method. Using a wash solution containing 10 per cent. HNO_3 (gr. 1.22) by volume gave the best results.

The solvent action of water alone or of $NaNO_3$ or KNO_3 solutions upon MoO_3 was found to be very small, that of stronger dilutions of HNO_3 was considerable. The solvent action of the wash solutions upon the yellow precipitate was found to be practically nil. An examination of the results obtained by the use of molybdate solutions made up by different formulæ showed that the official solution (O.A.C.) was best suited for materials containing low percentages of P_2O_5; for higher percentages the addition of more HNO_3 was advisable (5cc to each 100cc of the solution). With low P_2O_5 this degree of acidity caused a slower precipitation, but otherwise did not give any difficulties. The addition of organic acids to prevent coprecipitation of NoO_3 rendered precipitation slower but did not appear to afford the advantage sought. Investigation showed that 23. mols. Na_2CO_3 were necessary to neutralize the ammonium phospho molybdate containing one P_2O_5 mol. (confirming Pemberton's figure).

The results by this method, as compared with gravimetric results, average slightly lower, a fact believed to be in its favor, as the tendency in the gravimetric molybdate-magnesia method is to high results. The method is described (as modified) thus: Treat 2 gms. with 5 cc. $Mg(NO_3)_2$ solution, evaporate and ignite; dissolve in HCl. (This in the case of organic materials.) With ordinary fertilizers treat with 30 cc. conc. HNO_3 and a little HCl, or with 30 cc. conc. HCl, adding little by little 0.5 gm. $KClO_3$. If much Fe and Al are present, use (on 2 gms.) 15 to 30 cc. HCl and 5 to 10 cc. HNO_3. Make up to 200 cc., take 20 or 40 cc. according to the proportions of P_2O_5 present, and add about 5 cc. HNO_3 in the case where 30 cc. was used to effect solution, or 10 cc. of HNO_3 in the other cases. Neutralize with ammonia until a precipitate just begins to form, dilute to 60 or 100 cc. (the larger bulk for the higher proportion of P_2O_5), digest at 60 to 65° C., and add filtered MoO_3 solution in proportion just sufficient to effect complete precipitation. Let stand in the bath just 6 minutes. Filter rapidly, using the pump. Wash twice by decantation with dilute HNO_3 (75 cc. each time), once by decantation with the same amount of 3 per cent. KNO_3 or NH_4NO_3 solution, then on the filter with 200 cc. or more of water until no longer acid. Now wash the precipitate with filter back into the beaker, titrate with KOH, and back with HNO_3, using phenolphthalein indicator.

323.81 cc. normal KOH diluted to one litre will give a solution of which 1 cc.=0.001 gm. P_2O_5.

Sulphur in Pyrites. Joseph (Bull. Soc. Chem. du Nord. part 1, p. 6). 1 gramme of well dried pyrites is mixed with 5 grammes Na_2O_2 in a platinum crucible, and heated gently with a small flame which does not touch the crucible. In a minute or two the reaction begins which bring the crucible up to red heat. When it is over all, the S has been converted to Na_2SO_4. The crucible is but little attacked. If the Pt of crucible contains 10 per cent. of Ir, the attack is still less. Ni or Cu crucibles

are not satisfactory. To avoid spirting, all moisture should be excluded from the materials. It is well to keep the Na_2O_2 in a stoppered bottle under a bell jar, along with a vessel containing conc. H_2SO_4.

Von Asboth (Chem. Ztg. XIX. 598) after comparing the method with $KClO_3$ and HNO_3, that with alkaline nitrate and carbonate, and that with Na_2O_2 gives the latter the preference.

Potassium cyanate in cyanide. Schneider (Ber. XXVIII. 1540). KCyO gives a blue color with Co salts. The presence of KCy masks the reaction. HCy can, however, be expelled by passing CO_2 through a saturated solution of the salt, precipitating by alcohol, filtering, and repeating this operation on the filtered solution, heating on the water both at the same time. When all HCy is expelled $Co(C_2H_3O_2)_2$ will produce the blue color if KCyO is present.

Estimation of Cyanides, simple and compound. Clennell. (Chem. News, LXXII. 227.) This investigation was undertaken in connection with the examination of the liquors in the cyanine treatment of ores.

The presence of ferrocyanide in the $AgNO_3$ titration gives results somewhat high in determining *simple cyanide.* The error is less when the "iodine method" is used. Ferricyanide has much less influence with either method. Sulphocyanide causes difficulty with the $AgNO_3$ method by obscuring the end reaction. It has no apparent effect in the iodine method. $(NH_4)_2CO_3$ causes high results by the $AgNO_3$ method but these are obviated by the addition of KI. In presence of the alkaline double cyanides of zinc, the indications by both methods are quite indefinite. To estimate *Ferrocyanides* DeHaen's method, titration by $K_2Mn_2O_8$ in acid (H_2SO_4) solution is satisfactory in presence of simple cyanide or of ferricyanides.

To estimate *Ferricyanides* Lenssen's method with Mohr's modification is good. (KI and $Na_2S_2O_3$.)

Zinc double cyanides. If a known excess of standard K_4FeCy_6 is added and the solution acidulated, and titrated with standard $K_2Mn_2O_8$ (DeHaen's method) an approximate estimation of the Zn can be obtained. On acidulating, the Zn is separated as Zn_2FeCy_6 which is unaffected by the $K_2Mn_2O_8$. The difference between the amount of K_4FeCy_6 added, and that found, indicates the proportion of Zn. The per cent. of Zn found $\times 4$ gives per cent. of KCy which has combined to form K_2ZnCy_4.

Total cyanide. If excess of K_4FeCy_6 is added to a solution containing Zn double cyanide, and the resulting solution is titrated with standard I solution (with starch indicator). One may determine the equivalent in KCy of free alkaline cyanides, and zinc double cyanide. This does not determine ferro and ferricyanides.

Analysis of Cyanide solutions. Bettel. (Chem. News, LXXII. 286 and 298). For discussion of the reactions believed to occur, the original paper must be consulted. The methods given are:

1. *Free cyanide.* 50 cc. of solution is titrated with $AgNO_3$ to faint opalescence, or first indication of a flocculent precipitate. This will indicate, (if sufficient ferrocynide be present to form flocculent zinc ferrocyanide,) the free cyanide and cyanide equal to 7.9 per cent. of the potassic zinc cyanide present.

2. *Hydrocyanic acid.* To 50 cc. of the solution, add a solution of

(Na or K)HCO_3 free from carbonate or excess of CO_2 titrate as for free cyanide. Deduct the first from the second result = HCy.

1 cc. $AgNO_3 = \frac{0.04145}{5} = 0.00829$ per cent. HCy.

3. *Double cyanides.* Add excess of normal NaOH to 50 cc. of the solution, and a few drops of a 10 per cent. solution of KI titrate to opalescence with $AgNO_3$. This gives 1, 2 and 3. Deduct 1 and 2, gives K_2ZnCy_4 as KCy less 7.9 per cent.

A correction is here introduced. The KCy found in 3 is calculated to K_2ZnCy_4. Factor: KCy(as K_2ZnCy_4) × 0.9493 = K_2ZnCy_4. Add to this 7.9 per cent. of total, or for every 92.1 parts K_2ZnCy_4 add 7.9 parts. If this fraction, calculated back to KCy be deducted from 1, we get the true free cyanide (calculated to KCy).

4. *Ferrocyanides and Sulphocyanides.* (In presence of zinc.) A burette is filled with the cyanide solution for analysis, and run into 10 or 20 cc. N/100 $K_2Mn_2O_8$ strongly acidified with H_2SO_4 until color is just discharged. Result noted (*a*).

A solution of $Fe_2(SO_4)_3$ or Fe_2Cl_6 is acidified with H_2SO_4, and 50 cc. of the cyanide solution poured in. After shaking for about half a minute, the Prussian blue is filtered off, and the precipitate and paper washed. The filtrates is then titrated with N/100 $K_2Mn_2O_8$. (*b*).

Let (*c*)=cc. permanganate required to oxidize ferrocyanide.

Then *a*—*b*=*c*.

(c) 1cc. $N/_{100}$ $K_2Mn_2O_8$=0 003684 gm K_4FeCy_6.

(b) 1cc. $N/_{100}$ $K_2Mn_2O_8$=0.0001618 gm KCyS.

5. *Oxidizable Organic Matter in Solution.* Prepare a solution of KCyS so that 1 cc.=1 cc. $N/_{100}$ $K_2Mn_2O_8$.

To 50 cc. of the solution tested, add excess of H_2SO_4, and then a large excess of $K_2Mn_2O_8$. Keep at 60 to 70°C for an hour. Then cool, and titrate back with the KCyS solution.

Result=O consumed in oxidizing organic matter.
" " " " K_4FeCy_6.
" " " " KCyS.

Deducting that required for the last two, the remainder has been absorbed by the organic matter. Multiplying by 9 gives approximately the organic matter present.

To get accurate results for K_4FeCy_6 and KCyS, it may be necessary to shake the solutions up with powdered CaO and filter, which removes all oxidizable organic matter.

6. *Alkalinity.* The end reactions, on account of presence of HCy are not very sharp. One can however estimate:

With $N/_{10}$ acid	100 per cent.	KCy	with phenolphthalein indicator.
	79 "	K_2ZnCy_4	
With $N/_{10}$ acid	100 "	Zn in K_2ZnCy_4	with methyl orange indicator.
or	100 "	Zn & K in K_2ZnCy_4	
With $N/_{10}$ acid		K_2O in ZnK_2O_2	phenolphthalein.

7. *Ferricyanide.* Allow sodium amalgam to act on the solution for 15 minutes and then estimate ferrocyanide by $K_2Mn_2O_8$ solution. Deduct $K_2Mn_2O_8$ consumed by K_2FeCy_6 and KCyS, previously found. The remainder is calculated to ferricyanide 1cc. $N/_{100}$ $K_2Mn_2O_8$=0.003293 K_3FeCy_{12}.

8. *Sulphides.* These are seldom present in cyanide solutions. If present it may be separated by shaking with precipitated $PbCO_3$ and titrating with $K_2Mn_2O_8$ before and after.

9. *Ammonia.* Add enough $AgNO_3$ to (say 10 cc.) of the solution in quantity sufficient to completely precipitate all Cy compounds, then a few drops of normal HCl, make up to 100 cc., shake, filter, add 10 cc. of the filtrate to 150 cc. of water and distil, estimating the NH_3 in the distillate by means of Nessler.

Reagents for Nitrates. Deniges. (Chem. Ztg. XIX. 328.)

1. A reversal of Millon's reagent when used to detect phenol. The solutions are: (*a*) 1 gramme phenol; 4 cc. H_2SO_3 solution; H_2O 100 cc. (*b*) 3.5 grammes HgO; 20 cc. glacial $HC_2H_3O_2$; 100 cc. H_2O. After mixing, 0.5 cc. H_2SO_4 is added, and the mixture is filtered. For the test, mix equal volumes of *a* and *b*, boil, and add a few drops of the solution to be tested. Red coloration, if nitrate is present.

2. Dissolve 2 cc. of aniline in 4 cc. glacial $HC_2H_8O_2$ and dilute with water to 100 cc. For the test, boil 5 cc. of this solution with about the same bulk of the liquid to be tested. HNO_2 affords a yellow or orange color, passing to red on acidifying cautiously. Chlorates and nitrates do not interfere. Hypochlorites, Cl, and corresponding Br compounds do, also excess of acid.

3. Dissolve 1 gramme resorcin in 100 cc. of water, and add 10 drops H_2SO_4. Put 10 drops of the liquid to be tested in a tube, add 2 cc. H_2SO_4, and 5 drops of the resorcin solution. Shake. HNO_2 if present gives a carmine red or violet blue solution.

Nitrites in waters. Gill and Richardson. (J. Am. Chem. Soc. XVIII. 21.) A comparison of Trommsdorff's iodo-zinc starch method, with the naphthylamine test showed that in peaty waters, the peaty matter interfered with the formation of the starch iodide. On decolorizing by shaking with ("milk of alumina") pure $Al_2(OH)_6$ and filtering, concordant results were obtained.

The naphthylamine test is by far the most delicate, indicating 0.0001 part of N as N_2O_3 in 100,000 of water. The limit for the iodo-zinc reaction is in the neighborhood of 0.0002 part. With these degrees of dilution, the metaphenyl diamine gave no indications.

Kjeldahl process. Causse. (Bull. Soc. Chem. XIII. 636.) Speed is found to be detrimental to accuracy in this process. Heating until decolorization occurs does not always afford a complete conversion of the nitrogen to ammonia. The period of heating should be about one hour for every 0.1 gm. of nitrogenous material presumably present. Large proportions of metallic oxides as aids in the destruction of the organic matter are useless and even objectionable. When HgO is used the addition of alkaline sulphide to break up mercurammonium compounds gives but little gain, if any, in accuracy of results. The plan recommended is using about 0.3 gm. $CuSO_4$ with 20 cc. conc. H_2SO_4, boiling at least 3 hours, transferring to a distillation flask, overneutralizing with NaOH and distilling. The use of permanganate was not tried, nor is it thought advisable.

Water in Coal. Grittner. (Zts. f. Angew Chem. 1895, 309). Unless the drying is accomplished in an atmosphere of H_2 the coal will take up considerable amounts of O, and the loss does not represent moisture as usually reckoned.

Estimation of Oxygen. Clowes. (Proc. Lond. Chem. Soc. 1895, 200). If the alkaline pyrogallol solution contains too small a proportion of KOH (sc. NaOH) CO may be evolved, which vitiates the result unless the CO is afterward absorbed by Cu_2Cl_2. A solution containing per 100 cc., 10 gms. pyrogallol and 120 gms. KOH, allows of no evolution of CO.

Determination of Hydrogen Peroxide. Riegler. (Bull. Soc. Rom. IV. Nos. 3 and 4), With Ag_2O the reaction is: $3H_2O_2+2Ag_2O=3H_2O+Ag_4O+2O_2$ and afterward $Ag_4O=Ag_2+Ag_2O$.

Hence 1cc. O evolved=0.00228 gm. H_2O_2. By use of a burette connected with a eudiometer tube and provided with a stop cock funnel, a known volume of the solution to be tested is introduced, then 5cc. of a 5 per cent. $AgNO_3$ solution, which is followed by the drop by drop addition of 2 cc. of 10 per cent. NaOH solution. At the end of 10 minutes the gas volume can be read off.

Testing Glycerin for Dynamite Manufacture. Lewkowitsch (Chem. Ztg. XIX. 1423). Sp. Gr. should not be under 1.261.

CaO, MgO and Al_2O_3 should be absent.

Cl: 1 cc. of the glycerin diluted with 2 cc. water should not give strong turbidity with $AgNO_3$.

As: Render just alkaline with ammonia and add $AgNO_3$—no yellow turbidity should ensue.

Organic: Dilute 1 cc. to 3 cc.; add a few drops $AgNO_3$ and let stand 10 minutes. Brown or blackish coloration should not appear.

Total solid residue: Heat a weighed portion *slowly* to 160°C., adding a few drops of water from time to time. Residue should not be over 0.15 per cent.

Free acid: The sample should be neutral to litmus paper. It should also give give no flocks of elaidic acid on passing nitrous fumes into it. Finally the test of making nitroglycerin on a laboratory scale should be tried. The yield should be 207 to 210 per cent. (Theoretical=246.7 per cent.)

BULLETIN OF ALUMNI AND UNIVERSITY NEWS.

DEDICATION OF THE NEW SITE.

The Trustees have designated Saturday, May 2d, for the dedication of the new site and the laying of the corner-stones of Schermerhorn Hall and the Physics building. The programme, which is printed in full below, has been divided between the morning and the afternoon on account of the length of the exercises, and also to give the Alumni an opportunity of seeing the grounds and of holding a reunion. Invitations will be issued only to the Trustees, the Faculties and the Alumni for the morning ceremonies, and, at their conclusion, luncheon will be served

for the Trustees and Faculties in South Hall and for the Alumni in West Hall. The University Alumni Council will have charge of the luncheon in West Hall.

The afternoon exercises will be of a more formal and public character, and will take place in the South Court, where stands with a seating capacity of three thousand will be provided. A large number of official and other guests will be invited. All undergraduates will be asked to assemble in West Hall on the Boulevard near 118th street, at half-past two o'clock, and march in a body to the South Court, where seats will be reserved for them.

PROGRAMME.

Morning.

11.30 A. M.—Assembly of Trustees and Faculties in South Hall.
11.30 A. M.—Assembly of Alumni in West Hall.
12 M.—The Trustees, Faculty and Alumni will form in procession, the President and the Trustees leading, and proceed to
The Physics Building.—Dedication service; the Rev. Dr. Vincent officiating. Laying of the corner-stone by Professor Rood. Address by Dean Van Amringe.
Schermerhorn Hall.—Dedication service; the Rev. Dr. Dix officiating. Laying of the corner-stone by Mr. W. C. Schermerhorn. Address by Professor Osborn.
The order of the procession will then be resumed; the Trustees and the Faculties returning to South Hall, and the Alumni returning to West Hall, where a luncheon will be served.

Afternoon.

2.30 P. M.—Assembly of the Trustees, Faculties, speakers and official guests in South Hall.
2.30 P. M.—Assembly of the Alumni in the North corridor, and of the Undergraduates in the South corridor of West Hall.
2.45 P. M.—The President, Trustees, speakers and official guests will form in procession and proceed to the platform.
2.40 P. M.—The Alumni will form in procession and proceed by the way of the Boulevard and 116th Street to the South Court, where seats will be reserved for them.
2.45 P. M.—The Undergraduates will form in procession and proceed by way of the Boulevard and 116th Street to the South Court, where seats will be reserved for them.

Order.

3 P. M.—Prayer by the Rev. Dr. Edward B. Coe. Address by the President. Presentation of the National Colors by Layfayette Post, G. A. R. Acceptance of the Colors on behalf of the University by the President. Address by the Hon. Abram S. Hewitt. Address by President Eliot, of Harvard. Benediction by Bishop Potter.

Excavation is now in progress for five new buildings at the new site, viz., the Physics building and Schermerhorn Hall (for which the contracts are signed); the University building, which will contain the steam and power plant in the basement, and the general assembly hall, theater and gymnasium above; the Chemical building; and the Engineering building. The library is up to the first story and already shows the outlines of its superb proportions. At the meeting of the Trustees, April 6, a gift of $150,000 was received from the mother of the late Robert Center, being the estate of her son, to found a memorial professorship of music and fellowships or scholaships in this subject. Ten thousand dollars from an unnamed giver were received for the purchase of books for the library; four hundred and fifty thousand dollars for the construction of the chemical laboratory were also announced as presented by the members of the Havemeyer family.

surroundings and be free to observe natural objects and become familiar with them. He was a good amateur botanist, and always tried to know by name the plants and trees with which he came in contact.

In November, 1889, he married Miss Dorothea Marcus, who, with an infant son, survives him. ARTHUR HOLLICK.

Other notices have appeared in the *Engineering Record* of Dec. 28th, 1895, and the New York *Evangelist* of Jan. 4th, 1896.

NOTE.

The secretary of the class of 1878 has published a Memorial of Owen Frederick Olmsted, C. E., which will be sent on request.

There are in preparation memorials of Henry Albert Hodges, E. M., Anton Ferneks, E. M., and Gouverneur William Morris, E. M., for which reminiscences are requested; copies of these will be sent, when issued, to those furnishsng information to

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VOL. XVII. No. 4. JULY, 1896.

THE

SCHOOL OF MINES QUARTERLY.

A

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THE

SCHOOL OF MINES QUARTERLY.

VOL. XVII. JULY, 1896. No. 4.

THE GENESIS OF THE TALC DEPOSITS OF ST. LAWRENCE COUNTY, N. Y.

BY C. H. SMYTH, JR.

The field study upon which this paper is based was carried on while the writer was acting as assistant to Dr. James Hall, State Geologist. The geology of a portion of the talc district was outlined in the report for 1893,* and the economic side of the subject has been considered in a report just presented.† The purpose of the present communication is to review some of the matter contained in the earlier report, and to present certain phases of the subject not previously treated at any length.

While precise data are lacking, it is safe to say that about three-quarters of St. Lawrence county lie within the area of crystalline rocks constituting the Adirondack region. In this portion of the county the most abundant rocks are gneisses; the term gneiss being used in a very broad sense, and implying nothing as to the origin of the rocks. Much less extensive, but of great interest, both scientifically and economically, are the crystalline limestones, which form large irregular belts, with a general northeast and southwest trend, separated by areas of gneiss. Sometimes the limestone is sufficiently pure and uniform in color and composition

* Report of the State Geologist for 1893, p. 511.

† Report of the State Geologist for 1895, unpublished.

to be quarried for building and monumental marble; but more often it is unsuited for these purposes, commonly through the presence of various disseminated minerals. Of these, one of the most widespread is tremolite. Specimens of this mineral in handsome groups of crystals from localities in Gouverneur, Pierrepont, Russel, etc., are to be found in most mineral collections; but these represent exceptional occurrences, limited in number and extent.

More commonly, the tremolite forms very imperfect, bladed crystals scattered through the limestone, sometimes in such abundance as to constitute a tremolite schist. The individuals are very thin, elongated in the direction of the vertical axis and decidedly columnar or fibrous in structure. They are prevailingly white, though pink, brown and gray varieties appear at times. When the tremolite is in sufficient quantity to make up the bulk of the rock, it forms masses of interlocking fibers, in which it is difficult to distinguish any clearly defined individuals. Sometimes, enstatite is present in large amount, mingled with or taking the place of the tremolite in the schist. It is usually light colored or white, and so strongly resembles tremolite that the two minerals can hardly be distinguished in the field, requiring optical examination for their discrimination.

This phase of the limestone formation has its greatest development in the towns of Fowler and Edwards; and as it is here intimately associated with the talc deposits it is of importance in the present connection, affording, in fact, the best line of approach for the consideration of the talc.

The limestone of this belt is unusually impure, containing many layers of varying thickness, composed largely of silicates. Conspicuous among these is a thick body of tremolite and enstatite schist which stretches across part of Fowler and Edwards, a distance of seven or eight miles, and contains the important talc deposits. The strike of this rock is northeasterly, with a northerly dip varying from about 40° to vertical. In these large structural features it is quite conformable with the limestone, into which it gradually passes, both above and below.

The relations shown between this schist and the limestone, as well as similar phenomena repeated on a smaller scale at many points, seem to prove that they are different portions of one formation, which, as shown by the study of the geology of the region, must be regarded as of sedimentary origin. As will appear in the

sequel, this is an important point in tracing out the history of the talc deposits, and will require further consideration after the description of the latter.

The intimate association of the talc with the other silicates has been recognized in all descriptions of the deposits, but their structural relations have not been clearly described.

In most accounts* it is stated that the talc forms a clearly defined vein with walls of granite or gneiss, the vein being penetrated by, and including horses of, tremolite.

According to the writer's observations, the talc occurs in the form of beds, lying wholly within the schist of the limestone formation. These beds range in thickness from thirty down to a few feet, and sometimes pinch out. They dip and strike with the rest of the formation and have schist for both foot and hanging, sometimes with an intervening thin layer composed largely of quartz. There is little in the character of the beds to suggest a vein formation, while the walls of gneiss and granite are wholly lacking.

A brief examination suffices to show that, as might be expected, the association of talc with tremolite and enstatite schist is not fortuitous, but has a genetic basis. Between the two rocks there is a complete gradation, but not, as in the case of the schist and limestone, of such a character as to indicate that present differences are the result of primary variation. On the contrary, it is evidently a gradation resulting from secondary causes which have led to the conversion of tremolite and enstatite into talc.

The talc nearly always shows more or less of the bladed, columnar or fibrous structure which characterizes the tremolite and enstatite, although in some cases this structure becomes quite obscure. But the most compact and structureless talc shades off into the more abundant bladed variety, and this, again, into schist.

A specimen of the talc usually shows bladed and fibrous portions, with smaller quantites of scaly and wax-like materials. The color is greenish-white, with pearly, silky, or greasy lustre. In the eastern part of the belt the fibrous structure is generally very marked. Toward the west, this structure becomes less conspicuous, and the material is more compact with a considerable amount of the scaly variety. This is the so-called "foliated talc" and is well shown in the American mine in Fowler.

*A Sahlin Trans. Am. Inst. M. E. XXI., p. 583.
" " The Mineral Industry, I., p. 435.
C. A. Waldo, The Mineral Industry, II., p. 603.

Conclusions as to the relations between the two rocks, based upon field study, are entirely supported by microscopic examination. Sections of the talc show every stage from original tremolite or enstatite to a complete alteration of the mineral into talc. When crushed with a hammer, the softer specimens of fibrous talc yield a more or less coherent, felt-like mass of fibers, the length and toughness of the fibers varying considerably. Under the microscope, the coarser fragments are semi-transparent and closely resemble fragments of the original minerals, but have numerous fine, straight rulings parallel to the original cleavage. Subjected to pressure under a glass slip, these fragments separate into fibers parallel to the rulings, the number and fineness of the fibers being proportional to the pressure applied. Naturally, the transmission of light is much impeded, and the specimen, though thinned by the pressure, becomes decidedly less transparent. It is evident that the talc is not made up of bundles of loosely aggregated fibers, but of homogeneous masses, with a tendency toward a fibrous fracture. This fracture is parallel to the cleavage of the original mineral, so far as the vertical element of the latter is concerned, and is, in a sense, an inheritance from the tremolite or enstatite, by whose original structure it has been conditioned in its development.

In thin section, however, there are parts of the talc that consist of distinct fibres, often irregularly arranged. In some cases these appear to be direct products of growth of the mineral; but in others, and perhaps in all, they are the result of the application of pressure to compact, homogeneous masses like those described above. That the rocks have been subjected to much pressure is clearly shown by abundant slips and slickensides. In some thin sections there is good reason for believing that the fibrous structure has been made more evident by the pressure of grinding.

With crossed nicols, fragments of the fibrous talc show, usually, parallel extinctions, though occasional pieces extinguish at a moderate angle and must be regarded as partially altered tremolite. Convergent light shows an axial figure with the plane of the axis parallel to the rulings or fibrous structure. The axial angle is large as compared with that of typical talc. A very soft specimen, measured by the Mallard method, gave $2E = 56° 36'$; while a slightly harder piece gave $80° 34'$. Both of these specimens appear to be derived from enstatite. These figures differ widely from

that of Scheibe,* who gives 30–40° as the value of 2E. His measurements were probably made on more thoroughly altered material, the angle seeming to decrease, as might be expected, with the progress of alteration. The optical character negative.

The soft scales with pearly lustre, taken from specimens of the foliated talc, show, under the microscope, numerous fibres scattered through them, but with intervening spaces clear and colorless. With crossed nicols these scales remain nearly or quite dark during revolution, but with convergent light show a figure which closely approaches that of an uniaxial mineral. The optical character is again negative.

There is, thus, a pronounced difference in the behavior of the two varieties in convergent light, the fibrous showing a decidedly larger axial angle than the scaly. The latter agrees much the more closely in this respect with typical talc from other localities. This discrepancy raises a question as to the true nature of the fibrous mineral and an effort has been made to procure positive evidence bearing upon the matter. The character of the material is such as to make it difficult to procure satisfactory results from optical tests, but physical and chemical tests show that the mineral must be regarded as talc. The hardness and lustre of typical specimens indicate talc; while the difficulty of fusion, the giving off of a little water at high temperatures, and the bright pink color with cobalt nitrate, point in the same direction. The best evidence is, however, afforded by the chemical analyses, which, as shown below, approach as closely to the theoretical composition of talc as could be expected in a mass of such extent.

The want of agreement in the properties of the fibrous and scaly talc is doubtless to be explained by the fact that they have, in reality, been formed in different ways, in spite of their intimate association.

The fibrous talc, which makes up the bulk of the deposits, is essentially pseudomorphous in its origin. The facts observed indicate that it has resulted from the gradual alteration of enstatite or tremolite, the change taking place as a rule throughout the mass of the latter minerals by a progressive modification of their chemical composition, rather than by the growth of scales or fibres of talc from cracks and the margins of individuals. The latter is the common mode of alteration, but, although followed somewhat in the

* Zeits. Deutsch. Geol. Ges; XLI., p. 564.

present case, seems to be of minor importance. While this view presents some complications, it seems a necessary inference from the facts.

In dealing with alterations of this kind it is the molecule, rather than the mineral individual, that must be considered. The existence of individuals of an intermediate composition does not necessarily imply the existence of molecules of like composition, which would, of course, involve difficulties. On the contrary, such an individual would result from commingling of molecules having the two extremes of composition. In most cases the agents of alteration act along cracks and the margins of individuals, and, in consequence, all of the molecules adjacent to these are changed before the more remote parts of the mineral are affected. But it seems quite possible that, in other cases, the agent of change may act through the mass of the mineral in such a way as to lead to the alteration of many molecules, widely distributed. In the former case the secondary mineral would form clearly-defined masses in the primary mineral, the alteration being concentrated. In the latter case the entire mass would be an intimate mixture of molecules of the primary and of the secondary mineral, the alteration being diffused. The ultimate results, so far as composition is concerned, must be the same, although the second method would probably preserve more perfectly the structural features of the parent mineral.

Such a diffused alteration explains well the phenomena presented by the fibrous talc; but it must be admitted that there are difficulties in its application. For the conversion of the original silicates of magnesium, and of magnesium and calcium, into talc, a silicate of magnesium containing hydrogen, must result, in large part, from the action of circulating water; and alterations so produced generally are of the first type above described. It seems possible, however, that intense pressure might cause such a saturation of the mass with solutions as to bring about the diffused alteration.

But whether or not the change has progressed in the manner suggested, there is no doubt that the fibrous talc is strictly pseudomorphous in origin. With the scaly variety the case is different. While its materials are evidently derived from the other silicates, it is not a pseudomorph after the latter minerals, as its form clearly shows. It must be regarded as an entirely independent growth, just as though its materials had been derived from some totally different source.

It thus becomes apparent that the two varieties of talc are genetically distinct; and in a mineral of somewhat variable properties, this fact would seem to afford sufficient explanation for the discrepancies observed. Futhermore, it is only natural that the variety which is of independent growth should agree more closely than the pseudomorphous variety, with typical specimens of the mineral. These facts afford good reason for the retention of the term "Agalite" as a varietal name for fibrous talc, to distinguish it from the normal mineral.

The chemistry of the conversion of enstatite and tremolite into talc is, theoretically, quite simple, and may be expressed by the following equations:

Enstatite *Talc*

$$4\,MgSiO_3 + H_2O + CO_2 = H_2Mg_3Si_4O_{12} + MgCO_3$$

Tremolite *Talc*

$$CaMg_3Si_4O_{12} + H_2O + CO_2 = H_2Mg_3Si_4O_{12} + CaCO_3.$$

The substitution of H_2 for Ca in the latter reaction is quite in harmony with the generally accepted view that talc is an acid metasilicate $Mg_3H_2(SiO_3)_4$. Clark* has advanced abundant evidence in support of this supposition and against Groth's suggestion that talc has the constitution of a basic pyrosilicate, $Mg(Si_2O_5)_2(MgOH)_2$ derived from pyrosilic acid $H_2Si_2O_5$. The latter view does not accord as well with the derivation of talc from tremolite; and as it often is formed by the alteration of this or related minerals, additional evidence is afforded, as has often been pointed out, in support of the more generally accepted formula.

The essential agents of alteration are evidently provided by circulating waters holding CO_2 in solution; and many occurrences of talc pseudomorphs show that the change may occur under ordinary conditions of pressure and temperature. But in the present case the extent of the alteration and the homogeneity of the product indicate that the process was carried on under a uniformity of conditions that would probably occur only at some depth. The complete alteration of the minerals without the breaking down of their physical structure seems, moreover, to demand, as previously suggested, that the change must have occurred under considerable pressure. That such effects would be produced by the mere seepage of water under superficial conditions seems doubtful.

*Am. Jour. Sci. (3) XL., p. 306.

These inferences are, however, necessarily based upon limited data; and it is possible that all of the facts may be explained by the supposition that the original schist was so homogeneous as to yield a uniform product, the steep inclination of the beds being favorable to the transmission of water under ordinary pressures. Further light may be thrown upon these questions by future mining operations.

Considering its origin, the composition of the talc is surprisingly close to that demanded by theory. This is apparent from the analyses given below, of which the first two are taken from Dana's System of Mineralogy, page 679, and the third is kindly furnished by Mr. A. J. McDonald, Superintendent of the International Pulp Company.

	I.	II.	III.
SiO_2	60.59	59.92	62.10
Al_2O_3	0.13	0.50	. .
Fe_2O_3	. .		. .
FeO	0.21	0.76	1.30
MnO	1.16		2.15
MgO	34.72	31.37	32.40
CaO	. .	0 57	. .
Na_2O	. .	0.48	. .
H_2O	3.77	6.25	2.05
Total,	100.58	99.85	100.00

A striking feature of these analyses is the small amount of lime, as shown directly in II, and indicated by the totals in I and III. This shows both a very thorough alteration of tremolite, and a complete removal of the lime carbonate formed in the reaction, the latter effect, of course, being accomplished by an excess of CO_2, not shown in the equation given for the operation. But the small amount of lime further suggests the much more important conclusion that tremolite is subordinate to enstatite as a source of talc. The difficulty of distinguishing the two minerals in the field makes it hard to settle the question positively, but the structure of schist and talc indicate that enstatite may be the chief source in the eastern part of the belt, and tremolite in the western part.

The analyses are of interest, further, in connection with the question of the origin of the schist. It has been already stated that the field relations of the rock indicate that it is an integral portion of the crystalline limestone formation. According to this view, a part of the formation contained so much silica and magnesia that regional metamorphism converted it into a schist instead of a marble. As to the presence of the magnesia, no special ex-

planation is needed, for this is a common constituent of limestones; and while its mode of deposition is uncertain, that is a question quite aside from the present discussion, as well as one upon which the facts here obtained shed no light. But the very low percentage of alumina is a point of importance in this connection. Siliceous limestones are nearly always aluminous, as they contain the finer products of degradation, which are usually rich in alumina. If this was the case with the rock under consideration, it is difficult to account for the almost complete removal of alumina, usually one of the most stable of rock constituents. Nevertheless, alumina may be removed in solution, as shown by the formation of Bauxite* and by various alterations.† On the other hand, limestones do occur which are rich in silica and poor in alumina. It is probable that such a rock furnished the material for the production of the tremolite schist.

The small amount of alumina suggests that the schist may be a highly modified basic igneous rock such as, for instance, the pyroxenites, and related rocks of Maryland described by Williams.‡

The direct objections to this hypothesis are: the lack of structural evidence of an intrusive character, the schist appearing to be interbedded; the gradation of the rock into limestone; and the common occurrence of tremolitic limestones elsewhere in the region. In the face of these facts, very strong evidence would be required to establish the igneous origin of the schist, although it cannot be regarded as excluded from consideration.

As, in the foregoing pages, much attention has been given to obscure and difficult points in connection with the problem under consideration, it may be well to sum up briefly the more important conclusions to which the facts obtained seem to lead.

The deposits of talc are of complex origin, and the process which has led to their formation consisted of three distinct stages. First, there was formed an impure siliceous and magnesian limestone. Second, this rock underwent metamorphism and was converted into enstatite and tremolite schist. Third, this schist, by the action of water charged with CO_2, was converted into talc.

HAMILTON COLLEGE, CLINTON, N. Y.
April, 1896.

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*C. W. Hayes, Trans. Am. Inst. Min. Eng., XXIV, p. 243.

†J. Roth, Allg. u. Chem. Geol. I, p. 112.

‡American Geologist, IV, p. 35.

PHOTO-CRYSTALLIZATION.

FERDINAND G. WIECHMANN, PH. D.

Light is one of the forms taken by the radiant energy which emanates from the sun. It is well known that light—or possibly some other form of energy accompanying light—is able to bring about chemical and physical changes.

The influence of sunlight on sugar solutions has been noted at various times and by different observers. The earliest reference to an instance of this kind seems to be contained in an article published by Dr. C. Scheibler in 1861–62 in the Jahresbericht über die Untersuchungen und Fortschritte auf dem Gesammtgebiete der Zuckerfabrikation, Vols. I and II, p. 194.

Some years ago the present writer noticed an interesting case of photo-action. A solution of partially inverted sucrose was, under the influence of sunlight, transformed into a crystalline solid. This change in the state of aggregation was accompanied by chemical change; the original amount of invert-sugar in the solution, 84.8 per cent., was increased to 97.06 per cent. A memorandum of this observation was published at the time,* and as the matter seemed to warrant further and more careful study, after some preliminary trials, a series of experiments was planned and commenced in December, 1891. The observations then begun have extended over a period of four years, and a record of the work done is herewith given. In this connection it is a pleasant duty to acknowledge the valuable services of Mr. Edward C. Brainerd, to whom the writer is indebted for the analytical data presented.

The term, photo-crystallization, under which this article appears, has been coined by the writer because this word seemed to indicate most accurately the nature and character of the phenomena studied.

Photo-crystallization has been observed in solutions of sucrose, partially inverted, and in plates of solid (barley) sugar. This communication will, however, deal only with the investigation of the sucrose solutions. These sucrose solutions were made by dissolving sixty-four parts by weight of perfectly pure sucrose (polarization 100) in sixteen parts by weight of distilled water; this gave an 80 per cent. solution.

*School of Mines Quarterly, Vol. XIII, No. 2.

Partial inversion of this sucrose was effected by chemically pure hydrochloric acid, of specific gravity 1.20. Of this an amount was used equivalent to 0.025 per cent. of the weight of the dry sucrose employed, and equivalent to 0.02 per cent. of the weight of the solution.

The sucrose was dissolved at the lowest possible temperature, not above 90° C. The solution was cooled down to 80° C. and then the hydrochloric acid was added. Inversion was completed at 80° C., the different amounts of invert-sugar produced in the different solutions being secured by maintaining these solutions at the temperature named for a longer or shorter period of time.

The solutions thus prepared contained inverted sucrose to the extent of:

Solution A = 90.9 per cent.
" B = 80.6 "
" C = 58.0 "

Each of the three solutions was divided into halves, thus giving rise to:

Solutions A I, A II.
" B I, B II.
" C I, C II.

Solutions A I, B I, C I, were left as prepared, very slightly acid; solutions A II, B II, C II, were carefully neutralized with sodium bi-carbonate, methyl-orange being the indicator used.

These solutions were placed into eighteen white glass flasks, which were securely corked after introduction of the solutions. They were divided into three groups, each group consisting of the following six specimens, which contained, respectively:

Inverted sucrose	90.9	per cent.	Slightly acid.
"	"	90.9	"	Neutralized.
"	"	80.6	"	Slightly acid.
"	"	80.6	"	Neutralized.
"	"	58.0	"	Slightly acid.
"	"	58.0	"	Neutralized.

The three sets were numbered, respectively, from 1–6, 7–12, 13–18. Set 1–6 was exposed to direct sunlight, as far as the condition of the laboratory in which the work was done permitted; exposure of the laboratory was southwest. Set 7–12 was placed in diffuse daylight, but shielded from all direct sunlight. Set

13–18 was kept in a dark closet, from which, however, diffuse daylight was not absolutely excluded during all of the time, as the door had occasionally to be opened to remove articles from or place articles into the closet; still, practically, it was kept in darkness. These three sets were under continuous observation, and the following tables show the manner in which crystallization progressed in the solutions.

The letters A, B, C, D, E, F, employed, in the following tables are intended to indicate only the *relative* extent to which crystallization had advanced in any given set of specimens at the time when the observation was made. The letters of one series cannot be compared directly with those of another series, nor taken as expressing that the same degree of crystallization had been attained in both series. Wherever, however, one and the same letter is used for more than one specimen in the *same* series, this signifies that crystallization had advanced to an equal degree in the specimens thus marked.

Although the time of growth of the crystals in the various solutions differed greatly, the manner of growth was the same in all cases. The first crystals made their appearance in the body of the solution and settled to the bottom of the flask. Then the crystals began to grow upwards on the sides of the flask, the interior portion of the solution remaining fluid the longest.

The growths consisted of snow-white, crystalline nodules, which, through aggregation, gave rise to fern-like forms.

TABLE I.

SERIES I.

Exposed to Direct Sunlight.

	SPECIMEN NUMBERS.					
	1	2	3	4	5	6
State of Crystallization after — days.	90.9 Acid.	90.9 Neutral.	80.6 Acid.	80.6 Neutral.	58.0 Acid.	58.0 Neutral.
100	A	D	B	C	E	F No crystals.
135	Solid.	B	A	B	B	C No crystals.
170		B	A	B	B	C No crystals.
225		B	Solid.	C	A	D No crystals.
324		Solid.		Solid.	A	B 2 small crystals.
365					Solid.	A 7 small crystals.
531						A Crystals throughout liquid. About ⅓ of bottom of flask covered thinly by crystals.
628						A Crystals all through solution.
785						A do:
1095						A do:
1473						A Crystals all through mass. A semi-solid magma.

TABLE II.

SERIES II.

Exposed to Diffuse Daylight.

	SPECIMEN NUMBERS.					
	7	8	9	10	11	12
State of Crystallization after—days.	90.9 Acid.	90.9 Neutral.	80.6 Acid.	80.6 Neutral.	58.0 Acid.	58.0 Neutral.
100	A	E	B	D	C	F No crystals.
135	A	E	B	D	C	F No crystals.
170	A	E	B	D	C	F 2 small crystals.
225	A	E	B	D	C	F do:
324	A	E	D	C	B	F do:
365	B	E	D	C	A	F do:
531	B	D	C	A	A	E About 30 crystals on bottom of flask.
628	B	C	D	Solid.	A	E
785	A	A	B		Solid.	C Fine crystals all through the solution.
1095	Solid.		A			B Crystals all through solution and layer of crystals on bottom ½" thick.
1473			A			B Crystals all through the mass; semi-solid.

TABLE III.

SERIES III.

Kept in Darkness.

	SPECIMEN NUMBERS.					
	13	14	15	16	17	18
State of Crystallization after — days.	90.9 Acid.	90.9 Neutral.	80.6 Acid.	80.6 Neutral.	58.0 Acid.	58.0 Neutral.
100	E	C	A	B	D	F No crystals.
135	E	D	A	B	C	F No crystals.
170	E	D	A	B	C	F No crystals.
225	E	D	A	C	B	F No crystals.
324	E	C	A	D	B	F No crystals.
365	E	C	A	D	B	F One crystal.
531	D	B	A	C	B	E 6 crystals on bottom.
628	E	B	A	D	C	F
785	D	A	B	C	C	E
1095	C	Solid.	A	B	B	D A few crystals on bottom, all the rest is liquid.
1473	D ½ solid; liquid color of amber.		A Almost solid.	C ⅔ solid liquid of pale amb'r col'r.	B Very nearly solid. Sides hard, central portion a magma.	E do:

Table IV, which follows, is self explanatory.

TABLE IV.

Number of Sample.	Description of Sample.		Condition of Exposure.	Time, in days, from beginning of experiment to			Condition when Analyzed.
	Per cent. Invert.	Condition.		Appearance of First Crystal.	Complete Crystallization.	Analysis.	
1	90.9	Acid.	Direct sunlight.	25	127	273	Solid.
2	90.9	Neutral.	" "	25	281	333	"
3	80.6	Acid.	" "	25	225	273	"
4	80.6	Neutral.	" "	25	324	333	"
5	58.0	Acid.	" "	63	350	488	"
6	58.0	Neutral.	" "	99	....	1474	Semi-solid.
7	90.9	Acid.	Diffuse daylight.	25	1096	1114	Solid.
8	90.9	Neutral.	" "	25	...	859	Very nearly solid.
9	80.6	Acid.	" "	..	....	1475	$\frac{9}{10}$ solid.
10	80.6	Neutral.	" "	...	611	810	Solid.
11	58.0	Acid.	" "	..	692	810	"
12	58.0	Neutral.	" "	170	....	1476	Semi-solid.
13	90.9	Acid.	Darkness.	25	....	1484	½ solid; liquid amber color.
14	90.9	Neutral.	"	25	1091	1115	Solid.
15	80.6	Acid.	"	25	....	1485	Nearly solid.
16	80.6	Neutral.	"	25	....	1488	$\frac{9}{10}$ solid; pale amber liquid.
17	58.0	Acid.	"	...	....	1478	Very nearly solid.
18	58.0	Neutral.	"	365	....	1477	A few crystals in bottom, liquid amber color.

Inspection of this table shows the following effects of exposure to light. All specimens in series I (exposed to direct sunlight) which crystallized completely, had attained to complete crystallization long before any specimen in either of the other two series had reached this condition.

Thus, between the times of complete crystallization of No. 1, series I, and No. 10, series II, the first of series II to crystallize wholly, there elapsed 484 days. Between the complete crystallization of No. 1, series I, and No. 14, series III, the first of this series to crystallize completely, lies a period of 964 days.

All three series of specimens were kept in the same room throughout the entire time over which observation extended. Series II and III were therefore practically under identical temperature conditions. Series I, however, being exposed to direct sunlight undoubtedly received more heat-energy than the other series. Experiments in which this disturbing factor will be eliminated by filtering the sunlight through a concentrated solution of alum before it reaches the sucrose solutions, are contemplated.

From these data it appears that, *caeteris paribus*, photo-crystallization is directly proportionate to the intensity of illumination.

Nine specimens when taken for analysis were wholly crystallized. This is 50 per cent of the total number. These had turned solid in the following sequence and time:

Number of Specimen.	Time in Days.
1	127
3	225
2	281
4	324
5	350
10	611
11	692
14	1091
7	1096

In Series I, five out of the six specimens had crystallized completely, and it will be of interest to learn what relation the sequence of crystallization bears to the composition of the specimens and the conditions to which they were subjected.

From inspection it appears that the acid solutions crystallized earlier than the neutralized solutions of the same composition. Thus, the specimen containing,

90.9 %	invert-sugar,	acid,	crystallized	in	127 days.
90.9 "	"	neutral,	"	"	281 "
80.6 "	"	acid,	"	"	225 "
80.6 "	"	neutral,	"	"	324 "
58.0 "	"	acid,	"	"	350 "
58.0 "	"	neutral, did not crystallize.			

Furthermore it appears that of these three acid solutions, the one containing the highest percentage amount of invert-sugar, 90.9, was the first one to crystallize; next in order of crystallization was the specimen containing 80.6 % of invert-sugar, while the one lowest in invert-sugar, 58.0 %, was the last to crystallize.

To summarize, it appears that photo-crystallization of partially inverted sucrose solutions, under conditions as here studied, progresses most rapidly the stronger the light to which the solutions are exposed and the greater the amount of invert-sugar which they contain.

* * *

When these three series of solutions were originally prepared,

the amount of inverted sucrose in the same was determined in the usual manner, as invert-sugar, by Fehling's solution. However, after completion of the work thus far described, it appeared desirable to submit all of the specimens to a more exact analysis in order to learn more about their constitution.

Accordingly the sucrose, dextrose and levulose were, in each instance, individually determined. The author's method employed is here republished,* the [α] D value of levulose is taken as—93.8.

THE METHOD.

Preparation of Solution.—If not already in solution, make of the sample to be examined a solution of arbitrary density. Of course, it goes without saying, that this method is to be applied only in cases where no other optically active substances are present besides sucrose, dextrose and levulose, and that care must be exercised that no preliminary treatment of the solution shall influence its original power of rotation.

The specific gravity of the solution above referred to is accurately determined by balance, and from this value there are calculated, in the following manner, the number of grammes of solution which contain 10.000 grammes of dry substance: †

Ascertain the degree Brix corresponding to the specific gravity found. Divide 100 by the degree Brix; the quotient represents the number of grammes of solution which contain 1.00 gramme of dry substance. This value is multiplied by 10, and the product represents the number of grammes of solution, equivalent to 10.000 grammes of dry substance.

This amount is weighed out, placed in an accurately graduated 100 c.c. flask, and the solution in the flask is made up to 100 c.c. with distilled water.

The determinations to be made, are as follows:

Optical Examination.—Some of the solution is placed in a water-jacketed polarization-tube, a thermometer is inserted in the solution, and a reading on this solution is taken in the polariscope, at the temperature of 20° C.

The reading thus obtained must be reduced to the basis of a reading made in a 100 m.m. tube.

*From the SCHOOL OF MINES QUARTERLY, Vol. XIII, No. 3.

† This concentration is chosen because the specific rotary powers of the sugars, values needed in the calculation of results, vary with the concentration.

Furthermore, if a sugar-polariscope has been used for the observation, the reading obtained must be transformed into circular degrees. With a polariscope using 26.048 grammes as the normal weight, the factor 0.346 is used, for the sodium ray.

Gravimetric Determination Before Inversion.—Of the 10 per cent. solution, weigh out an amount equivalent to 1.0 gramme of dry substance. Make this up to 150 c.c., and of this solution take 24.4 c.c. equivalent to 0.1628 gramme dry substance. Take 50 c.c. of Fehling's solution,* heat to boiling; while boiling add the 24.4 c.c. of sugar solution, and boil for three minutes.

Then remove from flame, add cold distilled water, previously boiled, in order to cool the solution and prevent a further deposition of cuprous oxide.

Filter through a weighed asbestos filter, wash, first with boiling water, then with absolute ethyl alcohol, and finally with ether. Dry perfectly, cool and weigh.

Calculate the cuprous oxide to its equivalent of metallic copper, and from the copper thus found, ascertain the amount of sucrose corresponding.† From this figure the total reducing-sugars by adding $\frac{1}{20}$ to the sucrose value indicated.

Gravimetric Determination After Inversion.—Of the original 10 per cent. solution, weigh off an amount equal to 5.000 grammes dry substance; invert with 4 c.c. of concentrated HCl (specific gravity 1.20) by heating on boiling water-bath up to a temperature of 67° C. and maintaining the solution at that temperature for five minutes. Then remove the flask, cool it and its contents to the temperature at which the flask was graduated, and then make the solution up to 100 c.c.

Of the solution thus obtained take 20 c.c. and neutralize with sodium carbonate; then make up to a volume of 150 c.c. with distilled water; of this solution take 24.4 c.c., equivalent to 0.1628 gramme of dry substance, and proceed precisely as previously directed. Determine the value found, as before, from the table; the result obtained represents the total sugars present, *expressed as sucrose.* From this amount subtract the sucrose value found by prior determination,‡ and the difference represents the amount of sucrose actually present.

*Cupric sulphate cryst.: 34.639 grammes in 500 c.c. H_2O; Rochelle salts, 173.000 grammes in 400 c.c. H_2O; Sodic hydrate, 50.000 grammes in 100 c.c. H_2O.

† Table published by the German Government, Law of 1887; also in Wiechmann, Sugar Analysis, Table XI.

‡ That is, the amount as actually found by table, prior to the addition of $\frac{1}{20}$.

The results thus obtained represent: the polarization, in a 10 per cent. solution, of the three sugars combined; the total reducing-sugars present; the amount of sucrose present.

In cases where the reducing sugars, *i. e.*, the dextrose and the levulose together, exceed in amount the sucrose present, the gravimetric determinations before and after inversion should preferably be made according to E. Meissl's method for the determination of invert-sugar.*

CALCULATION OF THE RESULTS OF ANALYSIS.

Let:

a=amount of sucrose present.
b=amount of total reducing sugars present.
x=amount of dextrose present.
y=amount of levulose present.
s=the specific rotatory power of sucrose, divided by 100.
d=the specific rotatory power of dextrose, divided by 100.
l=the specific rotatory power of levulose, divided by 100.
p=polarization observed, expressed in circular degrees.

Then,

$$(as+xd)-yl=p.$$
$$(as+xd)=p+yl.$$
$$xd=p+yl-as.$$
$$x=\frac{p+yl-as.}{d}$$

Substituting this value of x in the equation

$$x+y=b$$

there results:

$$\frac{p+yl-as}{d}+y=b.$$
$$p+yl-as+yd=bd.$$
$$yl+yd=bd-p+as.$$
$$y(l+d)=bd-p+as.$$
$$y=\frac{bd-p+as}{l+d.}$$

As y represents the amount of levulose, y deducted from b will give at once the amount of dextrose. Or, if preferred, the value of x can also easily be calculated independently.

Analytical Results.—The analytical results secured were tabulated and here follow. Table V records the analytical data ob-

* *Zeitschrift des Vereines für Rübenzucker-industrie*, Vol. XXIX., p. 1034, and E. Wein: *Tabellen zur Quantitativen Bestimmung der Zuckerarten*, Table No. IV.

tained; table VI shows the percentage composition of the different specimens as calculated from these data.

TABLE V.

Number of Sample.	Polarization of a 10 per cent. solution at 20° C. in a 200 m.m. tube.	Amount of Copper Reduced.					
		After Inversion.			Before Inversion.		
		Duplicate Determinations.		Average of Dupl. Dets.	Duplicate Determinations.		Average of Dupl. Dets.
1	— 11.7	.2912	.2908	.2910	.2854	.2848	.2851
2	— 8.2	.2914	.2917	.2915	.2667	.2683	.2675
3	— 10.8	.2900	.2908	.2904	.2822	.2826	.2824
4	— 4.8	.2919	.2941	.2930	.2497	.2508	.2502
5	— 11.4	.2931	.2939	.2935	.2837	.2855	.2846
6	+ 9.4	.3001	.3009	.3005	.1863	.1852	.1858
7	— 8.9	.2765	.2800	.2783	.2721	.2710	.2715
8	— 6.3	.2960	.2968	.2964	.2717	.2708	.2713
9	— 1.4	.2808	.2806	.2807	.2691	.2695	.2693
10	— 4.0	.2929	.2939	.2934	.2490	.2510	.2500
11	— 9.6	.2840	.2846	.2843	.2778	.2788	.2783
12	+ 9.8	.3042	.3032	.3037	.1857	.1866	.1861
13	— 4.4	.2830	.2855	.2842	.2717	.2741	.2729
14	— 6.5	.2906	.2934	.2920	.2685	.2683	.2684
15	— 5.8	.2808	.2797	.2803	.2714	.2708	.2711
16	— 0.2	.3000	.2998	.2999	.2541	.2539	.2540
17	— 2.9	.2833	.2849	.2841	.2738	.2723	.2731
18	+ 9.0	.3033	.3045	.3039	.1871	.1868	.1869

TABLE VI.

Number of Specimen.	Percentage Composition.			Ratio:	
	Sucrose.	Dextrose.	Levulose.	Dextrose.	Levulose.
1	2.04	46.03	49.11	1	1.06
2	8.17	43.36	45.52	1	1.05
3	2.74	46.18	48 04	1	1.04
4	14.53	40.54	42.19	1	1.04
5	3.03	45.86	49.16	1	1.07
6	38.39	32.07	28 31	1	.88
7	2.27	46.11	44.18	1	.96
8	8.58	46.24	43.99	1	.95
9	3.85	53.63	35.87	1	.67
10	14.71	41.34	41.33	1	1.00
11	2.10	46.90	45.79	1	.98
12	39.44	32.10	28.34	1	.88
13	3.91	50.88	39.84	1	.78
14	8.11	45.52	43.60	1	.96
15	3.15	49.21	40.90	1	.83
16	15.70	46.23	37.86	1	.82
17	3.79	52.72	38.06	1	.72
18	39.21	31.47	29.28	1	.93

This table exhibits some interesting relations.

The sucrose originally present has been partly transformed into invert-sugar. The increase of invert-sugar over and above the amount originally present in the solutions can be gathered from the following:

TABLE VII.

Specimen Number.	Conditions to which specimens were subjected.		Percentage amount of Sucrose inverted.
1	Sunlight.	Acid.	7.06
2	"	Neutral.	0.93
3	"	Acid.	16.66
4	"	Neutral.	4.87
5	"	Acid.	38.97
6	"	Neutral.	3.61
7	Diffuse Daylight.	Acid.	6.83
8	"	Neutral.	0.52
9	"	Acid.	15.55
10	"	Neutral.	4.69
11	"	Acid.	39.90
12	"	Neutral.	2.56
13	Darkness.	Acid.	5.19
14	"	Neutral.	0.99
15	"	Acid.	16.25
16	"	Neutral.	3.70
17	"	Acid.	38.21
18	"	Neutral.	2.79

Inversion has proceeded very much more rapidly in the acid solutions than in the others. The amount of sucrose inverted in the corresponding members of each of the three series is fairly constant. Thus in:

Specimen Number:	Sucrose Inverted:
1	7.06
7	6.83
13	5.19
3	16.66
9	15.55
15	16.25
5	38.97
11	39.90
17	38.21

And again,

Specimen:	Sucrose Inverted:
2	0.93
8	0.52
14	0.99
4	4.87
10	4.69
16	3.70
6	3.61
12	2.56
18	2.79

These results were to be anticipated and are in perfect accord with the teachings of the ion-theory; inversion was more rapid in the acid than in the neutral solutions because the inversion of sucrose is proportional to the number of free hydrogen-ions present. The total amount of inversion produced is practically the same in the corresponding members of the different series, because the amount of acid used to produce inversion was the same in all instances.

The last two columns of table VI show the ratio which obtains between the dextrose and the levulose of the specimens analyzed.

Disregarding series and considering all of the specimens studied, it will be seen that in those which were wholly solid when analyzed, the dextrose-levulose ratio is as follows:

Specimen Number.	Ratio of Dextrose	to	Levulose.
1	1		1.06
2	1		1.05
3	1		1.04
4	1		1.04
5	1		1.07
7	1		0.96
10	1		1.00
11	1		0.98
14	1		0.96
Average,	1	:	1.018

That is to say, the ratio between the dextrose and the levulose in the crystalline solids is practically one to one.

This is confirmatory of the view generally accepted regarding the composition of invert-sugar, the molecular mass of which is expressed by the formula $2C_6H_{12}O_6$.

The existence of invert-sugar as a definite crystalline solid would thus seem to be clearly established. In recognition of this fact it appears to the writer that it would be entirely appropriate to designate this substance as *Invertose*, a name indicative of the origin of this sugar and at the same time suggestive of its individuality.

The sucrose found associated with the invertose in the specimens studied, ranges from 2.04 to 14.71 per cent. These crystalline compounds of sucrose and invertose may perhaps be likened to alloys, that is to say, they may be regarded as mixtures of definite compounds, combined in varying proportions.

CONTRIBUTIONS FROM THE ANALYTICAL LABORATORIES OF THE SCHOOL OF MINES.

A STUDY OF METHODS FOR THE DETERMINATION OF STARCH.

By H. C. SHERMAN.

Many methods have been proposed for the determination of starch. A list of the principal ones is appended to this paper. An examination of these methods shows that, while most of those pretending to general application are based on the hydrolysis of the starch and estimation of the resulting glucose, they differ widely in method of treatment.

The fact that most of these methods give high results when applied to materials containing much other insoluble matter (fibre) has been most clearly recognized and understood since the researches of Tollens and Stone have revealed the wide distribution and susceptibility to hydrolizing agents of the pentosans, xylan and araban, bodies bearing the same relation to the pentose sugars which starch bears to glucose. Of these xylan is most characteristic of grains and grasses.* Experiments on isolated xylan, and on natural products containing the same, show that it is af-

* Stone, Bull. 43, U. S. Dept. Agr., Div. Chem., p. 165.

fected by most acids almost as readily as starch, and more readily than any of the other insoluble carbohydrates which have been isolated from grains and studied.

Many important researches on food materials have been based on determinations of starch by methods devised before the isolation of the pentosans, and hence without a knowledge of their properties.

It seemed, therefore, of interest and importance to compare some of the methods most commonly used in the past with those now considered most promising, not only to determine how far the former may be applied with safety, but to indicate to what extent the results formerly obtained can be accepted as correct. Whenever possible, the accuracy of the different methods has been tested directly, and for the reasons given above, special attention has been directed to the pentosans.

The property of yielding furfurol on distillation with acids is usually considered as characteristic of the pentose carbohydrates and is possessed both by the natural substances and the sugars derived from them.* This furnishes a means of testing the solutions which we obtain in determining starch, to discover whether pentoses are present. A positive result shows at once that, other conditions being correct, our results will be too high from the reduction of Fehling's solution by the pentose. A negative test proves that no error is introduced from this cause. The manner in which I have applied this test is as follows:

Bring about 25 c.c. of the solution to be tested into a small lipped beaker, add the same volume of hydrochloric acid (25% HCl). This gives the acidity most advantageous to the production of furfurol. Cover with a watch glass and heat to boiling. When the mixture boils briskly, introduce a slip of filter paper moistened with anilin acetate (made by mixing equal volumes of anilin and strong acetic acid) into the escaping vapors. If furfurol is being given off, a bright red coloration appears. A comparison of tables I and II below shows a close relation between the results of these tests and the percentages indicated by the different methods.

* Cross, Bevans, and Beadle, in several publications have stated that the property of yielding large quantities of furfurol is also possessed by oxycellulose. Since, however, the latter, in the natural state, is less readily attacked than the pentosans, it may for our present purpose be disregarded.

Materials Employed.

The pure starch sample used was prepared by repeatedly washing good corn starch with dilute saline solution and water, and finally drying the purified product in the air. Careful determinations in duplicate showed: ash, 0.20 per cent.; moisture, 17.36 per cent.; starch, by difference, 82.44 per cent. The other samples were commercial products of apparently average quality. All were ground to pass the 60-mesh sieve. In every case the water-soluble matter was extracted before proceeding with the analysis. Failure to do this caused, in the case of the grains, errors of from two to five per cent. Previous extraction with ether was tried on the wheat flour and oat-meal but caused no difference in the results.

Inversion on the Sand Bath.

Hibbard* has proposed thirty minutes actual boiling on the sand bath, in lieu of two to two and one-half hours heating on the water bath, to effect the final inversion of the products of the action of diastase on starch. His results (volumetric) were identical by the two methods. I have made the following experiment: Equal portions of such a solution were treated with the same amounts of acid and inverted by the different methods, all the other conditions being exactly the same and the reducing power of the final solutions being estimated by boiling 25 c.c. exactly two minutes with excess of Fehling's solution. Results:

Inverted on sand bath. Practically colorless.

	Milligrammes Cu reduced.
	194.5
	194.4
	195.5
Average	194.6

Inverted on water bath. Very faint straw tint.

	Milligrammes Cu reduced.
	194.4
	194.3
	194.5
Average	194.4

* Jour. Amer. Chem. Soc., XVII, 1, 64.

In similar cases in the following work I have inverted in this manner and have had no reason to doubt the accuracy of the results.

Description of Methods.

The inversion methods have always been the ones principally used. These may be divided into four classes, according to the degree to which the inversion is carried before the removal of foreign matter from the influence of the solution, as follows: (a) Complete hydrolysis to glucose; (b) conversion to maltose and dextrin by ferments; (c) conversion to dextrins by acids; (d) solution without chemical change. The methods which have been studied will be taken up according to this arrangement. For reference see the appended list. Results are given in Table I.

(a) Sachsse's Method.

The sample (usually 2 to 3 grammes) is extracted with cold water and then brought into a flask with 200 c.c. water and 20 c.c. of hydrochloric acid (25%). Close the flask with a stopper bearing a reflux condenser and heat in the water bath for three hours. Filter and wash. Nearly neutralize the solution with caustic soda and make to definite volume. Determine dextrose by boiling 25 c.c. with excess of Fehling's solution, using Allihn's table. Dextrose ($C_6H_{12}O_8$) × 0.9 equals starch ($C_6H_{10}O_5$). It is evident that pentosans and other hemicelluloses, and the insoluble glucosides, all of which yield reducing substances on hydrolysis, will tend to vitiate the results whenever present.

(b) Maercker's Method.

Heat the sample (previously extracted with water) with 50 c.c. water to 90 degrees to jellatinize the starch. Cool to 65 degrees, add malt extract and maintain at 60 to 65 degrees for thirty minutes, and then add 10 c.c. of 1% tartaric acid, close in a pressure flask and heat at 135 to 140 degrees (3 to 4 atmospheres pressure) for thirty minutes. Cool and treat again with malt extract as before. Filter, wash, add one-tenth the volume of 25% hydrochloric acid, and invert the solution according to Sachsse's method, or by boiling thirty minutes on the sand bath. Determine glucose as under Sachsse's method.

Maercker's method has been quite largely used in Germany and to a less extent in this country. I find no information in regard

to the effect of high temperatures and pressure on the solubility of the pentosans. My own results indicate that they are less readily affected by this treatment than might be supposed.

(b) Diastase Method.

Reinke seems to have been the first to discard the use of pressure and tartaric when working with diastase or malt extract. The sample, previous freed from water-soluble matter, is heated to boiling with water to completely jellatinize the starch, then cooled to 62 degrees, malt extract added, and the whole kept at about this temperature till a drop no longer shows the starch reaction with iodine. Then filter, wash and invert the solution as described under Maercker's method. When working with samples containing but little fibre, it is well to add a little malt extract before heating as suggested by Hibbard.

The solution will filter more readily if the treatment with malt extract be continued about an hour. Even then the filtration may sometimes be very difficult, the filter quickly becoming clogged if suction is applied. In such cases I have found it convenient to cool the solutions, make to definite volume, filter through a dry plated paper, and invert 50 c.c. of the filtrate in a 100 c.c. flask.

Since diastase does not invert glucosides nor pentosans it follows that a substance to interfere with this method must be insoluble in cold water, soluble in water at 65 degrees, and must yield a reducing substance when treated with hydrochloric acid. An examination of the available literature failed to show any such constituent occurring in considerable quantity in grains or common grasses.

(c) Guichard's Method.

Boil the sample for fifteen minutes with 100 c.c. saturated oxalic acid. Filter and wash. To the solution add one-tenth its volume of nitric acid (36 degrees B.) and heat in the water bath for one hour. Clarify with bone black and polarize, calculating the readings to glucose. In obtaining the results given in the table, I substituted heating in the water bath for actual boiling with oxalic acid and estimated the final solution by Fehling's solution as usual, in order that the results might be strictly comparable with those obtained by the other methods.

(d) BAUDRY'S METHOD.

Take a normal weight of the sample (2.688 grammes for the Laurent polariscope), boil with 80 to 90 c.c. water and 0.4 to 0.5 gramme salicylic acid for forty minutes. Add water to nearly 200 c.c., cool, add a few drops of ammonia, and fill to 200 c.c. Filter and polarize in a 400 m.m. tube. A modification consists in heating one hour in the water bath instead of boiling. The rotation on which the above calculation is based, is $[\alpha]j=200.25°$.

As a rule I was unable to get solutions sufficiently clear to polarize. Of course the ordinary clarifying agents cannot be used. The two samples containing the largest amounts of pentosans were treated as above for one hour in the water bath, filtered, and the solution inverted with hydrochloric acid. The results are shown in the column headed "Baudry's Method Modified." Although the treatment appears quite mild, the results are both considerably too high.

(d) SALICYLIC ACID METHOD.

Weigh out one to three grammes of the finely ground material, extract water soluble matter, and then bring into a flask with 100 c.c. water and 0.5 gramme salicylic acid. Place in the water bath, heat to boiling, and keep in the boiling water till all the starch is rendered soluble (15 minutes), then filter quickly through muslin with suction and wash with hot water, or add water, cool, make to definite volume, filter through folded paper, and take an aliquot part of the solution. To the filtrate add one-tenth its volume of 25 per cent. hydrochloric acid and boil 45 minutes on the sand bath with reflux condenser and estimate glucose as usual.

To obtain the most accurate results, the time required to render all the starch soluble should be previously determined in each case. Five to ten minutes is usually sufficient. The residue after washing should be proved free of starch.

This method is the result of experiments on Baudry's process, but has only the solvent in common with the latter. Its chief interest lies in the fact that it gives fairly accurate results, even on the most difficult materials, without the use of diastase or other ferment. It is based on the observation that ½ per cent. salicylic acid, at the temperature of boiling water, renders all starch soluble (capable of being filtered) before the pentosans are sensibly attacked.

Tabulation of Results.

The results obtained by the different methods are shown in Table I. Table II, shows the results of qualitative tests for pentoses in the final solutions, from which the figures in the first table are obtained. The figures in 1, 2 and 3 are used to indicate the relative intensity of the positive tests.

Table I. Percentage of Starch by Different Methods.

Sample.	Malt Method	Maercker's Method.	"Salicylic Acid Method."	Sachsse's Method.	Baudry's Modified.	Guichard Method.
Pure Starch	82.49	82.39	82.33	82.30	82.33	82.50
Wheat Flour	66.55	67.15	66.84	68.35	..	..
Oatmeal	56.23	56.16	56.00	59.01	..	..
Graham Flour	55.32	..	55.66	58.63	..	..
Wheat Bran	20.97	21.07	21.57	38.82	29.74	31.36
Wheat Straw	4.39	4.80	4.41	22.69	5.33	8.93
Corn Fodder	0.96	..	0.92	20.13	..	..

Table II. Qualitative Tests for Pentoses in Solution.

Sample.	Cold Water.	Malt Method.	Maerckers.	Salicylic Acid.	Sachsse.	Baudry.	Guichard.
Wheat Flour.	1	0	0	0	?	..	..
Graham Flour.	?	0	..	0	1	..	..
Wheat Bran.	0	0	?	1	3	2	2
Wheat Straw.	0	0	0	0	3	?	2
Corn Fodder.	0	0	..	0	3	..	..

The above results indicate that:

1. The diastase or malt method, properly executed, gives satisfactory results and cannot be vitiated by the presence of any substance now known to occur in considerable quantity in cereals or the more common grasses.

2. The results shown by Maercker's and the salicylic acid methods are, in the main, fairly comparable with those of the diastase method, and the final solutions contained, with a single exception, only questionable traces of pentoses or none at all.

3. No methods based on the chemical transformation of starch by acids before removal from other substances present can be accepted as generally applicable to the above classes of materials.

4. A qualitative test for pentoses in the final solution serves as a valuable check in working with any of the inversion methods.

PRINCIPAL METHODS PROPOSED FOR THE ESTIMATION OF STARCH.

A. Inversion Methods:

CHITTENDEN, Studies from the Lab. of Physical Chem., Yale Uni.; Jour. Anal. Chem., II, (1888), p. 153. Starch is dissolved by neutralized saliva, maltose and dextrin being formed. These are converted to glucose by HCl.

EFFRONT, Bul. Soc. Chim., 47, 5; Jour. Anal. Chem., I, 430. Starch is treated with diastase and the resulting maltose and dextrin determined as such.

GUICHARD, Bul. Soc. Chim., 7 (Ser. 3), 554. Dissolve by heating with saturated oxalic acid. Invert with HNO_3. Polarize the glucose solution and calculate to starch. See Stone, Bul., 43, U. S. Dept. Agr., Div. Chem., p. 162.

LINTNER, Zeit. Augew. Chem., 1888, 1, 65. Starch is rendered soluble by heating under pressure with water alone. Filter through glass wool and invert solution by HCl.

MAERCKER, Landw. Versuch Sta., 25, 107, used this method in his earlier analysis. It is sometimes called Maercker's Earlier Method. See Winton, Jour. Anal. Chem., II (1888), 155.

MAERCKER, Zeit. Anal. Chem., 24, 617; Chem. Zeit., IX, 319; Jour. Anal. Chem., II, (1888), 156. Starch is dissolved by diastase, heated 30 minutes, under pressure with dilute tartaric acid, filtered and inverted as usual. See Milkowski: Zeit. Anal. Chem., 29, 134. Winton, Jour. Anal. Chem., II, 156.

REINKE, Zeit. Anal. Chem., 29, 472, omits the use of pressure and tartaric acid. See Stone, Bul. 43, U. S. Dept. Agr., Div. Chem., p. 166.

HIBBARD, Jour. Amer. Chem Soc. XVII, 1, 64, adds malt infusion before jellatinizing to prevent balling. In inversion, boils on sand-bath with HCl instead of heating in water bath.

O'SULLIVAN, Jour. Chem. Soc., XLV, p. 1. Soluble carbohydrates, fats and albuminoids are first removed and the material then treated with diastase. Starch is calculated

from the reducing power and opticity of the solution. The specific gravity serves as a check.

REMPEL, Ber. Deut. Chem. Ges., 18, 621, dissolves by heating under pressure with dilute tartaric acid.

REINKE, Zeit. Anal. Chem., 29, 472, substitutes lactic acid.

SACHSSE, Chem. Centbl., 1877, 732, inverts with HCl directly. See Lintner & Dull, Zeit. Angew. Chem., 1891, 537, Analyst, 1891, 216; Winton, Jour. Anal. Chem., II, 153; Stone, Bul. 43, U. S. Dept. Agr., Div. Chem., p. 162; Hibbard, Jour. Am. Chem. Soc., XVII, 1, 64.

HORN, Chem. Tech. Anal. Org. Stoffe, heats under pressure before inversion.

DRAGENDORFF, Plant Analysis, p. 84, removes other substances liable to interfere by treating with alcoholic KOH, then inverts with HCl.

B. Polarization of Soluble Starch:

BAUDRY, Rev. de Chim. Ind., 5, 81; Zeit. Spiritus Ind., 15, 41; Chem. Centbl., 1892, I, 339, 509; Agl. Sci., 7, 186. Dissolve by heating with salicylic acid or $ZnCl_2$, filter and polarize. $[\alpha]_j^{18} = 200.25°$. See Deltour, Bul. Ass. Chim. Belg., 6, 154; Chem Zeit. Rep., 17, 42; Stone Bul. 43, U. S. Dept. Agr., Div. Chem., p. 162.

OST, Chem. Zeit., XIX, (1895), 1501. Analyst, XX, 235, 226. Solution obtained by heating with water under pressure. $[\alpha]_D = 196.7°$.

C. Precipitation of Soluble Starch by Alcohol.

HONIG, Chem. Zeit., 14, 868, 902; Jour. Anal. Chem., V, 234. Sample is heated with glycerine, cooled, starch precipitated alcohol and ether, and subsequently removed by HCl from the insoluble fibre (cellulose).

LECLERC, Jour. de Pharm., 21, 641; Bul. 31, U. S. Dep't. Agr., Div. Chem., p. 62. Dissolved by $ZnCl_2$ at 108 degrees, precipitate by alcohol, filter and weigh.

D. Precipitation of Starch-paste by Baryta.

VON ASBOTH, Repert. Anal. Chem., No. 20; Chem. Zeit., 13, No. 37, 591; Analyst, XII, 138; Jour. Anal. Chem., II, 162. See Spence, Jour. Soc. Chem. Ind., 7, 77; Jour. Anal. Chem., III, 22; Seyfert, Zeit. Augew. Chem., No. 5, (1888), 126; Milkowski, Zeit. Anal. Chem., 29, 134; Winton, Jour.

Anal. Chem., II, 162; Stone Bul. 43, U. S. Dept. Agr., Div. Chem., p. 162.

VULTE, Trans. of N. Y. Academy of Sciences, Oct., 1890. Describes the details most efficient in preventing the absorption of CO_2 from air and shows the calculation of the factors used.

E. Loss of Weight:

ALLEN, Com. Org. Anal., Vol. I, second edition, p. 344. Starch is calculated from increase of specific gravity of the malt extract on solution of starch in same.

KRUGER, Fort. Chem. Nahrung., 9, 567, Chem. Centbl., 1895, I, 1085. Weigh out two samples. Wash one with solution of SO_2. Treat the other with malt extract. Difference of weight equally starch.

F. Colorimetric Determination with Iodine:

DEMISTADT and VOIGTLANDER, Chem. Centbl., (1894) II, No. 5, 322.

G. Calculation from Specific Gravity:

a. Tables and formulas for potatoes. Behrend, Maercker and Morgan, Agric-Chem. Centbl., 1880, 452; Horn. Chem. Tech. Anal., 64. Heidespreim, Jour. Chem. Soc., XXXII, 233. Pohl, Weiner Academie-Berichte, VIII (1852), 42. Post, Chem. Tech. Anal., 861.

b. Formula for commercial starch. Saare, Jour. Soc. Chem Ind., III, 527. Allen, Com. Org. Anal., Vol. I (2nd), p. 346.

c. Apparatus for measuring water displaced. Girard, Aime and Flourent, Centbl. Agric-Chem., 21, 858.

THE INSTRUCTION IN ARCHITECTURAL DRAWING AT COLUMBIA UNIVERSITY.

By PROFESSOR WILLIAM R. WARE.

(*Concluded.*)

III. Graphical Construction.

The painter, like the sculptor, employs in his composition natural forms, and the skilful and accurate representation of real objects is his main work. But the architect, like the musician, and like the potter, the weaver and other workers in the arts of design, himself creates the forms which he employs in his compositions, so that skill in representing what he sees is of less importance to him than the power to give shape to his own conceptions, to what is visible to the eye of his mind. We accompany these exercises in Tracing and Copying, accordingly, and employ the handiness they develop, by exercises in what, for lack of better names, we may call Graphical Construction and Graphical Discussion.

For these a few hours' preliminary discipline in drawing straight and curved lines, so that they shall be of even and uniform tenor, amply suffices. It is excellent practice to put down dots at random and to connect them by a firm and clear stroke, straight or curved. If the dots are set so that the result is a geometrical or decorative figure, or resembles a building, a vase, or any other object, so much the better.

Among the exercises given under this head are:

1. *A Diaper Pattern.* An oblong, about eight inches by twelve, is carefully laid out and each side divided into four parts. Then diagonals are drawn, cutting up the surface into diamonds, each side of which is then divided into three parts, and a right-angled triangle erected upon each middle part as a hypothenuse. This gives eight-pointed stars, alternating with pointed crosses. Each of these figures is then divided into eight or four parts by lines drawn across their centres, joining the opposite internal angles. The pattern thus formed is sometimes shaded with parallel lines, in one or two tints, according to each student's judgment or fancy.

This exercise gives capital practice in drawing straight lines, long and short, and serves besides to illustrate two important

points. The first is that, in any work containing several repetitions of the same figure, they should all be drawn, so to speak, at once. The pattern, as thus laid out, shows twelve stars and eight half-stars. If these twenty figures were taken in hand one by one, each being finished before the next was begun, the task would become tedious almost beyond endurance before its end was reached. Moreover, the last star would either be better done than the first, after all this practice, or worse done, through loss of interest and the weariness of the flesh. In either case the work would lack uniformity and one part would disparage the other.

This disparity is avoided if the twenty figures are made to advance simultaneously, *pari passu*, all the horizontal lines being put in first, then the vertical ones, then the inclined ones, those that are paralled to each other being taken together. If there is any loss or gain in point of execution it is thus spread over the whole drawing and does not show anywhere. Moreover, and this is the second point, the work becomes largely mechanical. It is chiefly the work of the hand and the nervous system. The eye and mind are hardly called upon. This is a great gain. The weariness that comes in drawing the same thing twenty times over is a mental fatigue. Each repetition involves a dozen readjustments of observation, intention and volition, and the spirit flags before the task is half accomplished. But if all the similar strokes are thus made at the same time, a single effort of eye and mind suffices for the whole. Pains is taken with the first, but all the rest do themselves. The strain upon the attention is relieved, and by the time the bottom of the drawing is reached one feels quite rested and is ready to start again.

The drawing of parallel lines, indeed, becomes in this case so automatic that I have often found this spontaneous work of the hand more accurate than that of the careful eye. The diagonal lines will run so true as to correct errors made in laying out the original points of division. One can, indeed, almost work with his eyes shut.

When the shading is completed it is instructive to notice how many different designs result, and how much simpler the pattern looks than when shown merely by the lines.

This principle of working all over the field at once applies, of course, to any case of uniform repetition, such as, for instance, a row of Corinthian capitals. It is almost impossible, otherwise, to make them look alike.

2, 3. Practice in drawing geometrical curves is found in drawing a sphere, with great circles and small circles upon its surface, projected as ellipses, and in making diaper patterns of intersecting and concentric circles. These and other patterns are, like the first, shaded in two or three flat tints with parallel lines.

4. *The Fleur-de-Lys.* The fourth example affords practice in drawing curved lines of a freer character. A rough sketch is made on the blackboard, and each student draws as graceful and well-proportioned a *fleur-de-lys* as he can devise, studying the form with tracing paper until it suits his taste, and then carefully drawing half of it. The rest of the work consists in repeating these lines, reversing them so as to complete the figure. Plate XIII.

To this end, instead of using guide-lines as auxiliaries, as is often done, roughly conformed to the shape of the figure, we take a hint from the differential calculus and indicate the points of maxima and minima, the points of contrary flexure, and the terminal points, or cusps, noting in the last two the directions of the tangents to the curve and the points where these tangents would cut the central axis, if prolonged to meet it. At the maxima and minima points the tangents are either vertical or horizontal, and do not need to be indicated, these points sufficing to give both the position and the direction of the curve at its highest and lowest parts and at its extreme limits right and left. If now, the direction of these several points from each other is noted, two and two, and the point where a line joining them would cross the axis is also indicated, it is easy to find the position of the corresponding points on the other half of the figure. These points give the position and direction of both ends of each portion of the curve that lies between them, and it only remains to connect these points by lines of a proper character, circular, elliptical or hyperbolic.

If a number of such figures are to be drawn, they need to be drawn simultaneously, as has just been suggested for Corinthian capitals, to secure similarity of touch. But in this exercise we generally avoid the tedium of doing exactly the same thing three or four times over, and yet secure the advantage of going through the same motions three or four times, by repeating the figure on a smaller scale. Each repetition takes less time than the last, and while rehearsing all that is most valuable in the experience, introduces a useful variety into the manipulations. It requires a nice touch to draw a *fleur-de-lys* only half an inch high.

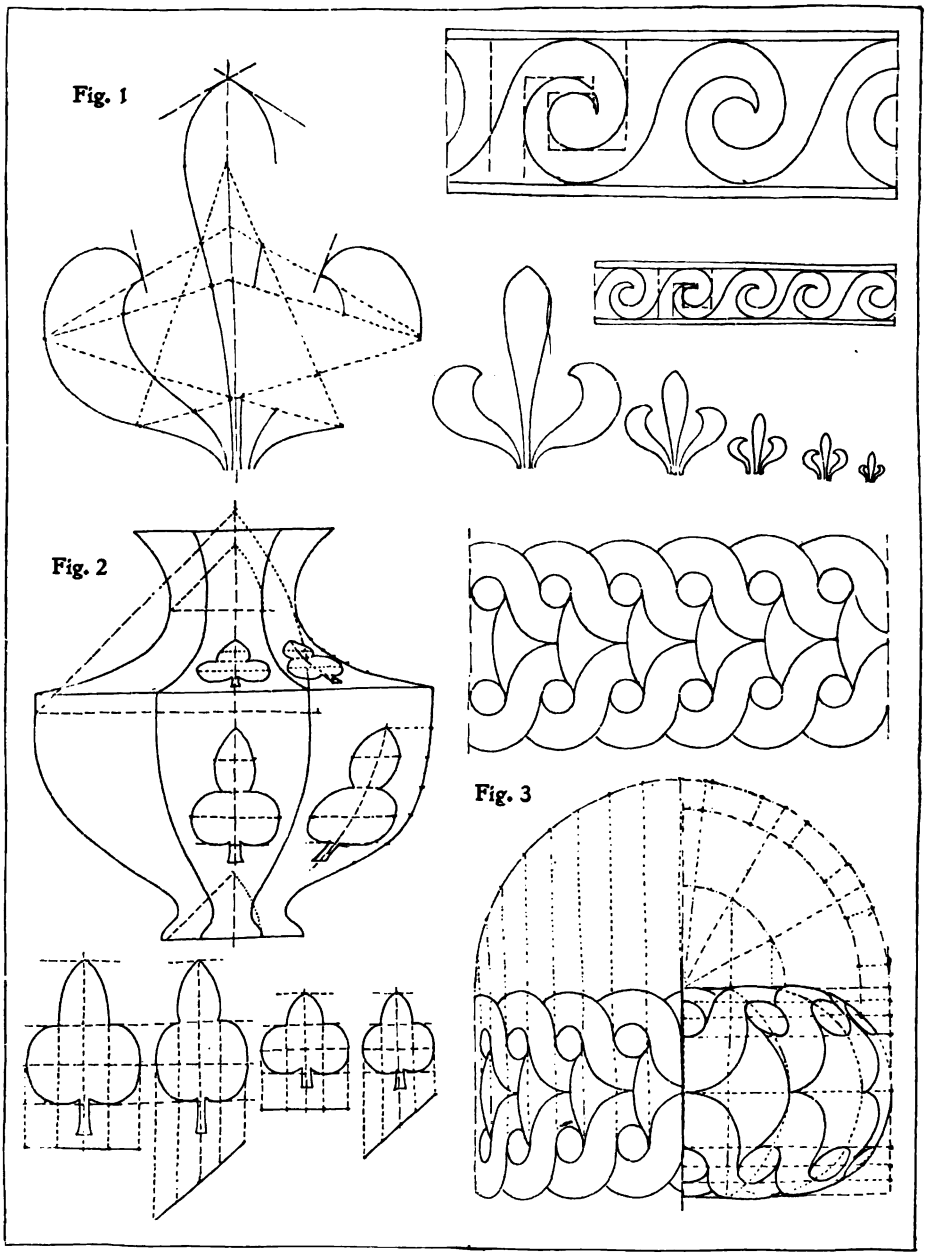


PLATE XIII. GRAPHICAL CONSTRUCTION. *First Year.* A. R., M. R. S.

Fig. 1. The Fleur de lys. *Fig. 2. The Octagonal Vase.* *Fig. 3. The Guilloche.*

5. *An Octagonal Vase.* Here also the form of the subject is left to each student's taste and fancy. The outline of one side of the vase being determined, and its width, that is to say the position of its central axis, the outline of the other side is found as in the previous exercise. Points on one of the front corners of the octagon are then found for each different diameter by drawing a line at 45° from one extremity of the diameter to the axis and revolving it down. One of the corners may then be drawn through these points and the other copied from it. This is an admirable exercise in freehand projection. Plate XIII.

6. *A Guilloche.* This is drawn as a flat pattern, either single and double, and then again foreshortened, as if applied to a cylinder or torus. Plate XIII.

7. *Leaves.* A plain leaf, drawn in three elevations, front, side, and at 45°, first flat, and then with the point bent over, is an excellent introduction to the study of the acanthus leaf in similar aspects. This prepares the way for the study of the Corinthian modillion, and this for the Ionic and Corinthian capitals.

In all these cases no copy is set, but a rough indication is given on the blackboard showing the kind of thing to be done. Everybody's interpretation differs, of course, from everyone else's.

The elementary principles upon which this work depends are simultaneously taken up in a mere formal manner in the course in Projections, and are further illustrated and applied in the study of Shades and Shadows. Since architectural forms are for the most part made up of regular geometrical solids, such as cylinders, cones and parallelopipeds, and since the light is, in an architectural drawing, supposed always to have the same direction, and the Shadows are generally supposed to fall upon vertical surfaces, it follows that the number of different shaped shadows that occur in practice is more limited than might be supposed. The same forms are constantly recurring, just as, in multiplication the same factors are constantly furnishing the same products. Now just as in arithmetic, it is worth while to tabulate these results and to learn the multiplication table by heart, so here it is a convenience to frame rules for these shadows, so that they may be drawn whenever they occur by memory. We find it in fact almost as easy to make rules for the shapes of the shadows as for the shape of the columns and entablatures themselves, and they are as easy to learn as to make. These rules transfer the subject of Shades and Shad-

ows from the field of geometry to that of draughtsmanship and enable a student to put them into his work as readily as the forms that cast them. The forms of both substance and shadow thus become so familiar that only care and attention are needed in drawing them, not computations and reasonings.

These exercises excellently exemplify the kind of drawing which is specially characteristic of the Architect. Every line, though executed with the free hand, is determined in shape, size and position by geometrical considerations. Thoughtless and careless work is out of the question. Draughtsmanship of this sort is an intellectual exercise. It has an educational value quite apart from its practical uses.

The habit of thinking with the pencil in hand which these exercises tend to foster, and of giving to every form as it presents itself to the imagination a concrete existence, is indeed a habit eminently conducive to clear and consistent thinking on every subject into the conception of which the idea of space naturally enters. Even in Geometry, Analytical Geometry, and the Calculus, students and teachers are much in the habit of saving themselves the trouble of making drawings and of relying upon the vague images formed in their minds by a not too representative imagination. In Mechanics especially there is a particular advantage to clear thinking in substituting the forms of things for names. But even in Arithmetic and Algebra the relations of abstract quantities, too often hidden behind the apparently perspicuous grammar of the phrases in which they are stated, may be made surprisingly obvious if translated into the language of form.

IV. Graphical Discussion.

The next procedure has still more distinctly an educational and disciplinary character, inasmuch as it exacts, besides accuracy of hand and eye, a still larger measure of mental activity. It consists of a series of exercises in which the object drawn is depicted in every variety of aspect, a simple barn or dog kennel, for instance, which is the object generally chosen to begin with, being shown in plan, with three elevations, two sections, a plan of the roof, a perspective plan, a perspective view and a bird's-eye view; ten sketches in all, all with the shadows cast. After two or three of them are drawn it is easy enough to do the rest. The labor of understanding the forms is at a minimum, but to maintain con-

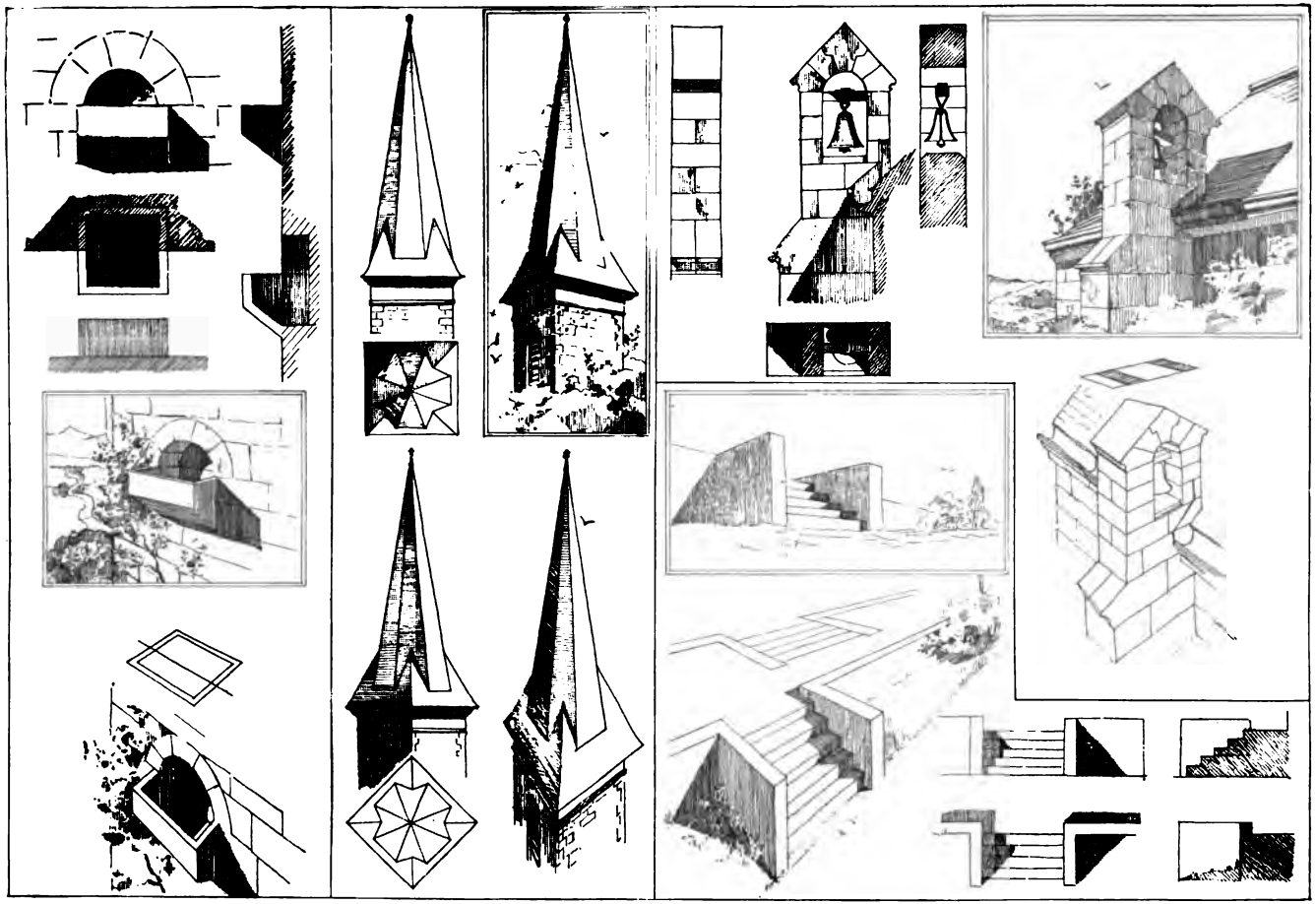
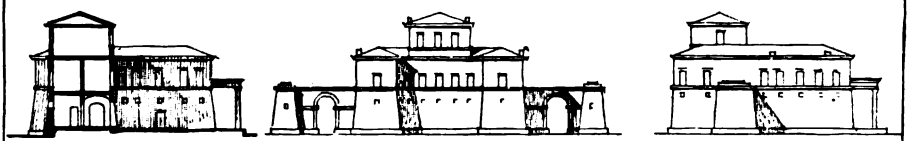
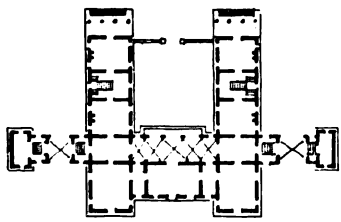
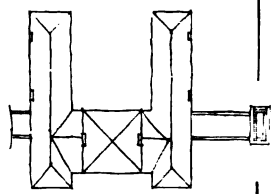
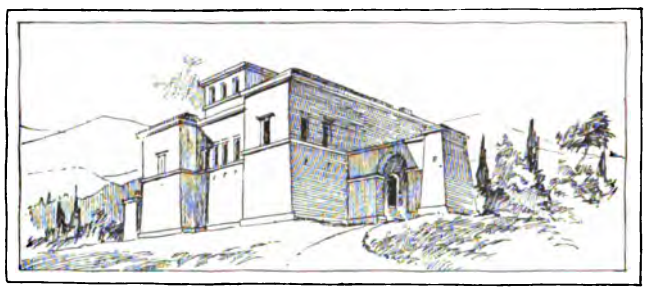


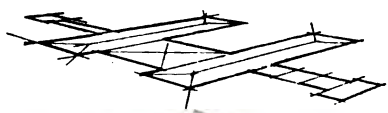
PLATE XIV. GRAPHICAL DISCUSSION. *First Year.* W. F. B., C. A. H., H. N. H. JR.











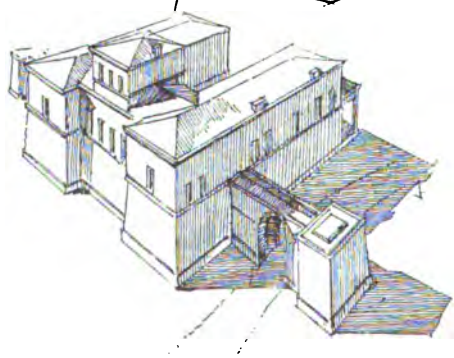


PLATE XV. GRAPHICAL DISCUSSION. (*First Year.* W. F. B.

Plan and elevation given. The rest inferred.)

sistency of size and proportion among them all requires a constant observance of their relations. Plate XIV.

The exercises under this head begin with simple forms, such as a barn, pyramid, or other geometrical solid, and go on to steps, chimneys, belfries, towers and spires, and finally to buildings and parts of buildings of any degree of complexity. Their value as affording practice in thinking in three dimensions, in conceiving an object in the solid, and distinctly apprehending its various aspects, will readily be understood by any one who knows how difficult it is for many persons to exercise their minds in space. They not only cultivate the imagination, however, but, by affording a complete graphical discussion of every object taken up, tend to form a habit of thorough and exhaustive investigation which is of real educational value. It is largely because the Classical Languages and Mathematics and the Natural Sciences afford examples of exhaustive discussion that these studies are accorded the place they hold in general education. An exhaustive graphical treatment of any object is not less exemplary, and for the student of Architecture it can hardly fail to be of special and immediate service. A designer trained in this discipline is hardly likely to rest content unless he knows how the back or side of his building is going to look, and is likely to feel uncomfortable unless he can see, in his mind's eye at least, how his roofs are going to go.

Meanwhile the student is obtaining much valuable experience; his knowledge and comprehension of form is enlarged, and the phenomena of Projections, Shades and Shadows, and Perspective, become so familiar through mere use and observation that when these subjects come to be systematically studied he finds himself upon familiar ground. Being already accustomed to the facts he finds it comparatively easy to comprehend the laws that they illustrate.

The extension of these discussions to the study of whole buildings, upon a small scale, easily follows, and forms an instructive experience in planning and in the composition of masses. Plate XV.

After one or two plates have been traced or copied so that the method may explain itself, it suffices to give the student two or three sketches, showing the object in two or three aspects. These are enough to start with. He then works out the other half dozen drawings for himself, inferring what can be inferred from the data furnished, and supplying the rest from his reason and imagination, or from the memory of previous studies.

By including in the series the details of the classical orders these forms also are made familiar. The student becomes acquainted with them in themselves, as works of art, in advance of taking them up scientifically and learning their numerical proportions. The numerical relations of these parts are indeed important and necessary to know. But this knowledge should come merely as an auxiliary and as a safeguard against error, after acquaintance has been made with the forms themselves and the student has learned to draw them from memory and to care for them for their own sake.

V. Brush Work.

These exercises in Tracing, Copying, Graphical Construction and Graphical Discussion, executed for the most part with the pencil or pen, occupy rather more than half the time given to drawing during the first year, three or four hours in the morning being devoted to them every week and three hours in the afternoon every alternate week. One afternoon a week is given to them in the second year, and in the third year an hour or two a week is given to pen drawing. The historical drawing done in the second and third years, in illustration of the work of Historical Research which occupies the chief part of the spring, suffices to keep up and further to perfect the skill thus acquired.

The afternoons of the alternate weeks during the first year are given to Brush Work with India ink and colors, the intermediate weeks, as has just been said, being given to Pencil Work. These exercises amount to a dozen or twenty in number, being about one for each week devoted to them, and are arranged so as to give a considerable variety of practice in the rendering of plans, elevations and details. The series of exercises for the last year was as follows:

1. Practice Sheet of India Ink Washes.

2. Large Porch with Steps, from Durand, in color, with the shadows cast.

3. Elevation from Scheult's *Recueil d' Architecture.* This is a collection of Italian villas, farm-houses, houses, granaries, fountains, etc., drawn in outline with an indication of background and foreground. They measure only three or four inches, but are enlarged by the students to twice or thrice their original dimensions, the shadows cast, and walls, roofs, sky, trees, hills and foreground put in in color, each student taking a different example. Plate XVI.

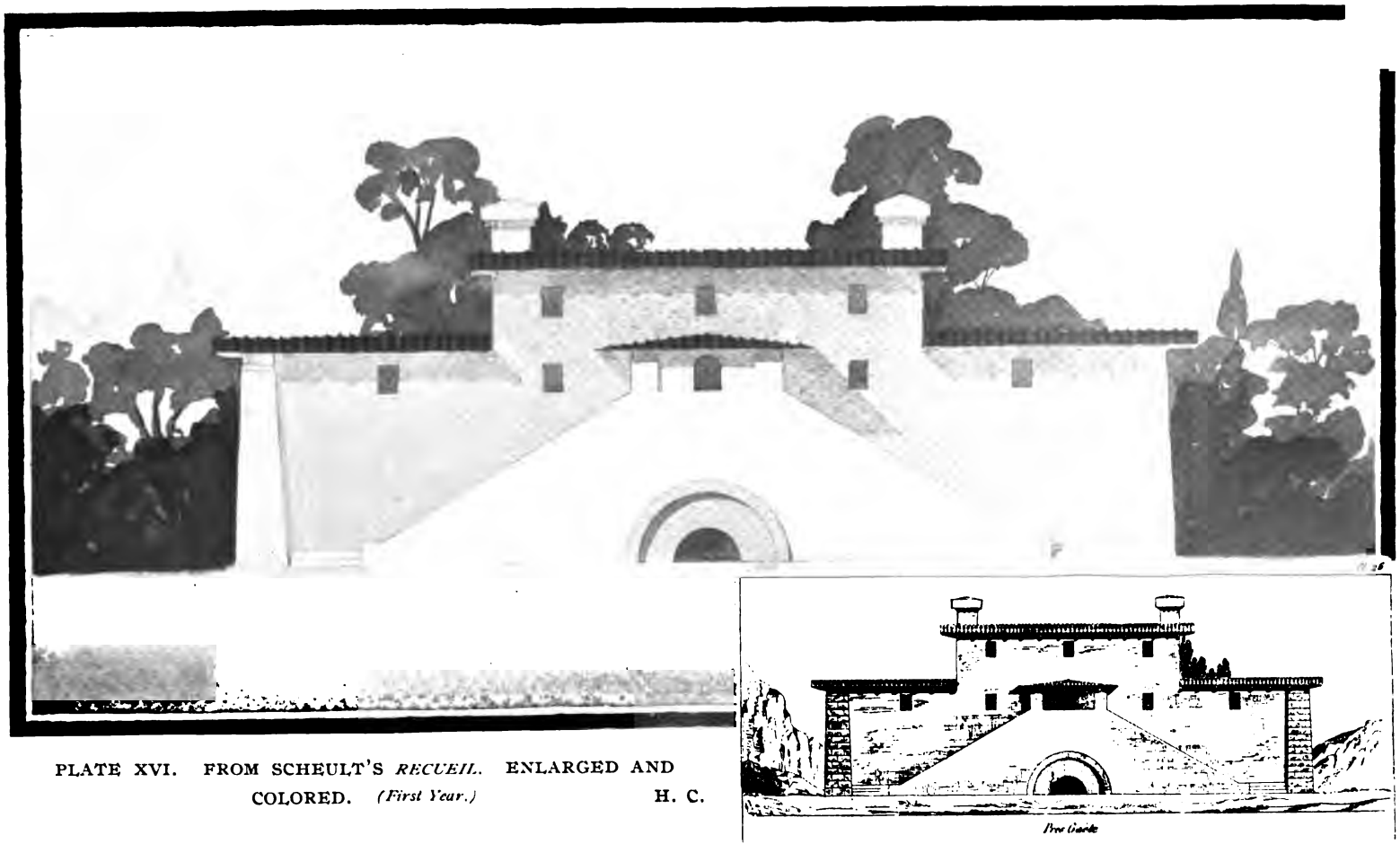


PLATE XVI. FROM SCHEULT'S *RECUEIL.* ENLARGED AND COLORED. *(First Year.)* H. C.

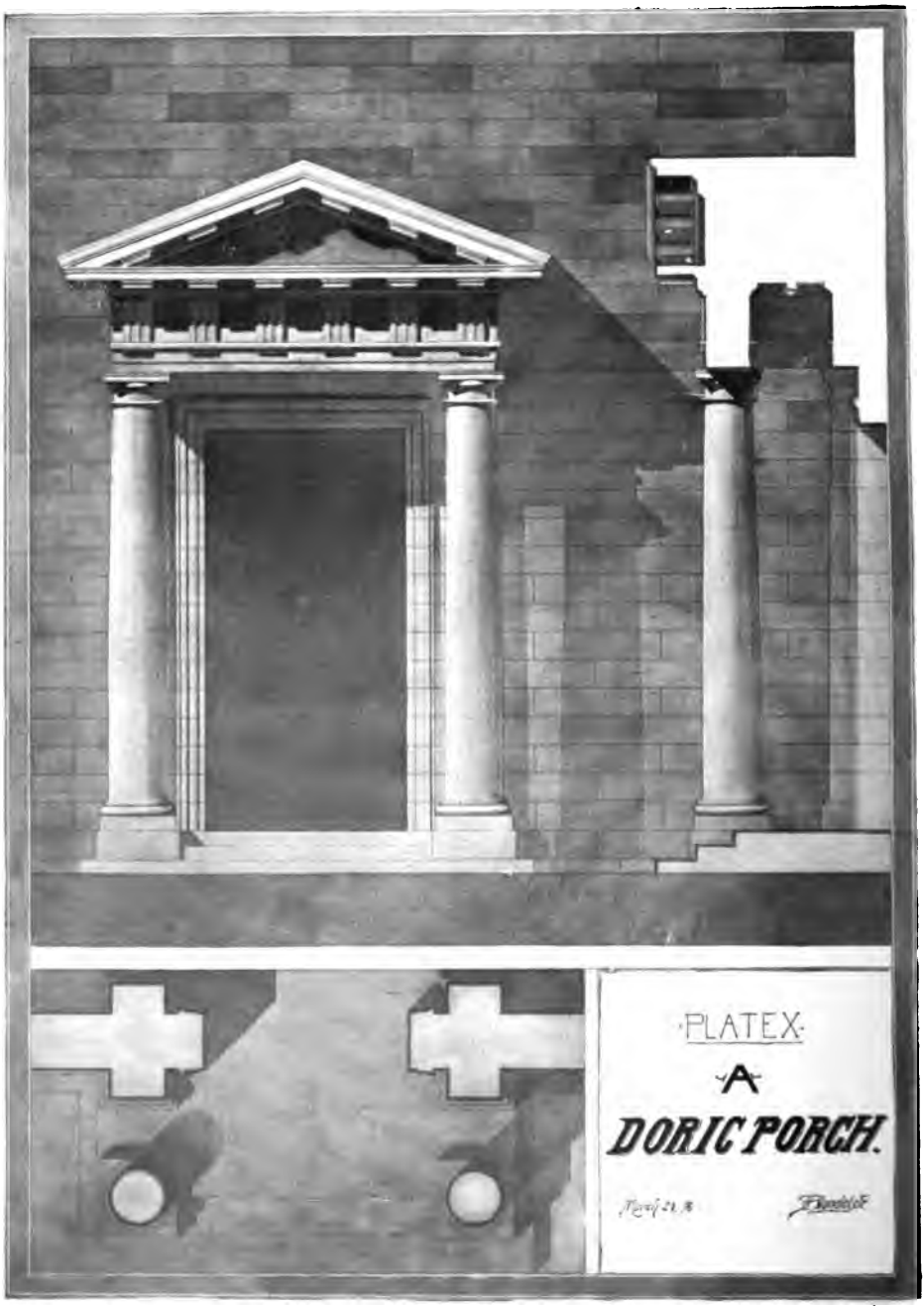


PLATE XVII. A DORIC PORCH.

4. The Tomb of Scipio Barbatus, rendered in India Ink.

5. A Modern Cottage.

This serves to explain constructions in wood. Plan, section and details are traced from a diagram, and then re-drawn to a different scale and rendered in color.

6. A Stone Portico.

This is a similar exercise for constructions in stone.

7. A Tower. Elevation and Perspective.

This subject is given in plan and elevation by a diagram, drawn out by each student from his own sketch, with the aid of a little elementary instruction in perspective, and rendered in color.

8. A Figure in Flat Washes.

This is an exercise in drawing sculpture as it needs to be drawn in connection with architecture. A figure is traced from a print or photograph, the main line dividing the light side from the dark side is found, and the dark side shaded with a single flat tint. The figure is then reduced in size several times by the method of squaring, until the smallest drawing is about as large as the figures of statues introduced into drawings of buildings. Each student draws a different figure. Plate III.

9. Another example from Scheult, with the plan and ornamental grounds added. (A side elevation, also, such as may easily be inferred from the other, is sometimes required).

10. The Tuscan Order, at a two-inch scale.

11. The Doric Order, at a one-inch scale, applied to a doorway. Plate XVII.

12. The Ionic Order, at a three-inch scale.

13. The Corinthian Order.

The class had not yet learned their Orders, and these plates were made merely as drawing exercises. But they had by this time learned their Shades and Shadows, and the shadows were accurately cast, rendered in India ink, and the plates colored.

14. A large plan, with gardens, rendered in color.

15. A large elevation, rendered in color with the shadows cast.

By this time the class had learned their orders.

The exercises in historical drawing which occur in the last half of the second and third years afford opportunity for further practice with the brush both with color and with India ink, and this is made the most of. But of course the chief application and development of the skill attained by the elementary exercises of the first

year is found in the rendering of the plans, elevations and details, the study and designing of which is the chief work of the second, third and fourth years.

In the fourth year also, the class have regular instruction and practice in water colors, and in the drawing and rendering of architectural perspectives. The skill thus gained is turned to account in rendering ornament with the brush, instead, as before, with pencil, pen and charcoal.

It is an interesting variation of these exercises to copy in water colors a picture painted in oils, or to copy a photograph or engraving, imitating the handling and coloring of a water-color drawing of similar character, as is done in the plates from Scheult. Plate XVI. The inverse process, that of copying in India ink or sepia, or with the pencil or pen, drawings or paintings in color, is even more instructive, since it involves a solution of the difficult problem of rendering the relations of colors, and their *values*, by means of black, white and gray. All these exercises tax to the utmost the student's judgment and skill, and often bear witness in the result to interesting diversities of personal predilection. Like the drawings made in copying photographs or lithographs, these are exercises rather of translation and interpretation than of direct imitation, and like them are a capital preparation for drawing from nature.

These works of various draughtsmenship illustrate, indeed, in a marked degree, the principle which guides and governs all the work of the school, in every branch of study, the principle of defining the student's work within strict limits, so as to make sure that he traverses every portion of the ground that he is required to go over, but within those limits not only permitting, but obliging him to think for himself, try his own experiments and trust to his own wits in shaping his answer to the questions that present themselves. Even in the Mathematics and Mechanics every fresh point is presented by preference as a problem to be solved rather than as a theorem to be demonstrated. As was said of the historical problems described in a previous paper, if the student can find an answer for himself he had better do so. If he cannot, the attempt makes the answer more intelligible and more welcome when it is told him. So in this work with pen, pencil and brush the student is shown just what he is to do, and the principles he is to follow are explained to him. But in the application of them he is left largely to his own devices.

— ORCHESTRA FLOOR PLAN —

.II. MEASURED WORK. THE GARDEN THEATRE. H. S. H., H. H.

VI. Outdoor Sketching.

All the men in the three upper classes study buildings in the city and make from them measured sketches during the first four or five weeks of the year. This is of great service in helping them to understand and feel the relations that exist between drawings and the things they represent. Similar exercises form a portion of the work required to be done during the three summer vacations.

In the prosecution of this work two squads, of about twenty men each, last year attacked the City Hall and Trinity Church and, by the favor of the Mayor and of the Wardens, were enabled to make fairly complete drawings of both those buildings. This year a still larger number of men, organized in squads of three, cach under the captaincy of a fourth-year man, made measured drawings of a large number of buildings and parts of buildings, public and private, a work for which their owners kindly offered every facility. Plate XVIII.

VII. The Orders.

In all this work the objects drawn are mainly of an architectural character. Even the purely geometrical figures are the elements out of which architectural details are composed; the vases, foliage and flowers are either themselves examples of architectural ornament, or are the originals which have suggested it; and the same may be said even of the studies in sculpture and the human figure.

These exercises, including, as they do, the drawings made in connection with the study of history, make the men fairly familiar with most of the more common architectural forms. But there is a certain class of architectural details which, not only from their unique position, both in the history and in the practice of the art, but also from their intrinsic quality, require a closer study. The Greek and Roman columns and entablatures, and the forms of doors, windows and other features, which, in earlier or later times have been devised to accompany them, are at once the final fruit of all the Egyptian and Oriental art that comes before them and the source and inspiration of all the mediæval and modern architecture that has followed. They form, moreover, at the present day, the habitual medium of architectural expression in every civilized country.

To learn to employ the Orders in architectural compositions is a part of the study of design. But the study of these elements of

design themselves is a branch of architectural drawing and comes properly within the subject of this paper. The experiments and criticisms, the variations and selections, of two thousand years, while they have evolved a great number of species, so to speak, of this genus, have, as in the natural world, determined the limits of profitable variation in each within narrow bounds, so that it is possible to define what may be called their normal types with something of geometrical and even of arithmetical precision. With these types it is necessary that the architectural student should become perfectly familiar, so that he may employ them in his thinking and in his drawing with as little hesitation as he employs his multiplication table, or the vocabulary of daily conversation.

The task proves, happily, on investigation, to be less formidable than might be thought. Their very universality makes these forms familiar to the eye, and it is almost as easy to learn how they go as to learn a popular tune. Their quantitative determination, so as to get them just right, is more difficult, and is rendered particularly so by the cumbrous systems of modules and minutes which the text-books, from the time of Alberti and Vignola, have employed. A little study, however, shows that the use of a scale of parts, which are according to Vignola twenty-fourths or thirty-sixths of a diameter, and according to other authorities sixtieths, is quite unnecessary. It is perfectly practicable to define all the dimensions which it is important to define at all, in terms of the sixth part of a diameter, for all the Orders. The diagrams which illustrate these results are made accessible to the students by means of *blue-prints*. Plate XIX.

This study, under the name of the Elements of Architecture, is taken up in the middle of the first year, and is expanded so as to include the discussion of such features as staircases, arcades, vaults, domes and spires. Formerly we began this arithmetical study of the Orders at an earlier moment. But it proved to be a mistake to approach the subject on this side. It was like making the acquaintance of flowers through a botanical dictionary instead of in a garden. The students, we found, were prone to regard these masterpieces of art, not as graceful and beautiful, but as containing so many sixths. We now, as has been said, begin with them as works of art, drawing and sketching them for their own sakes. By the time there rules are given out the capitals and cornices have

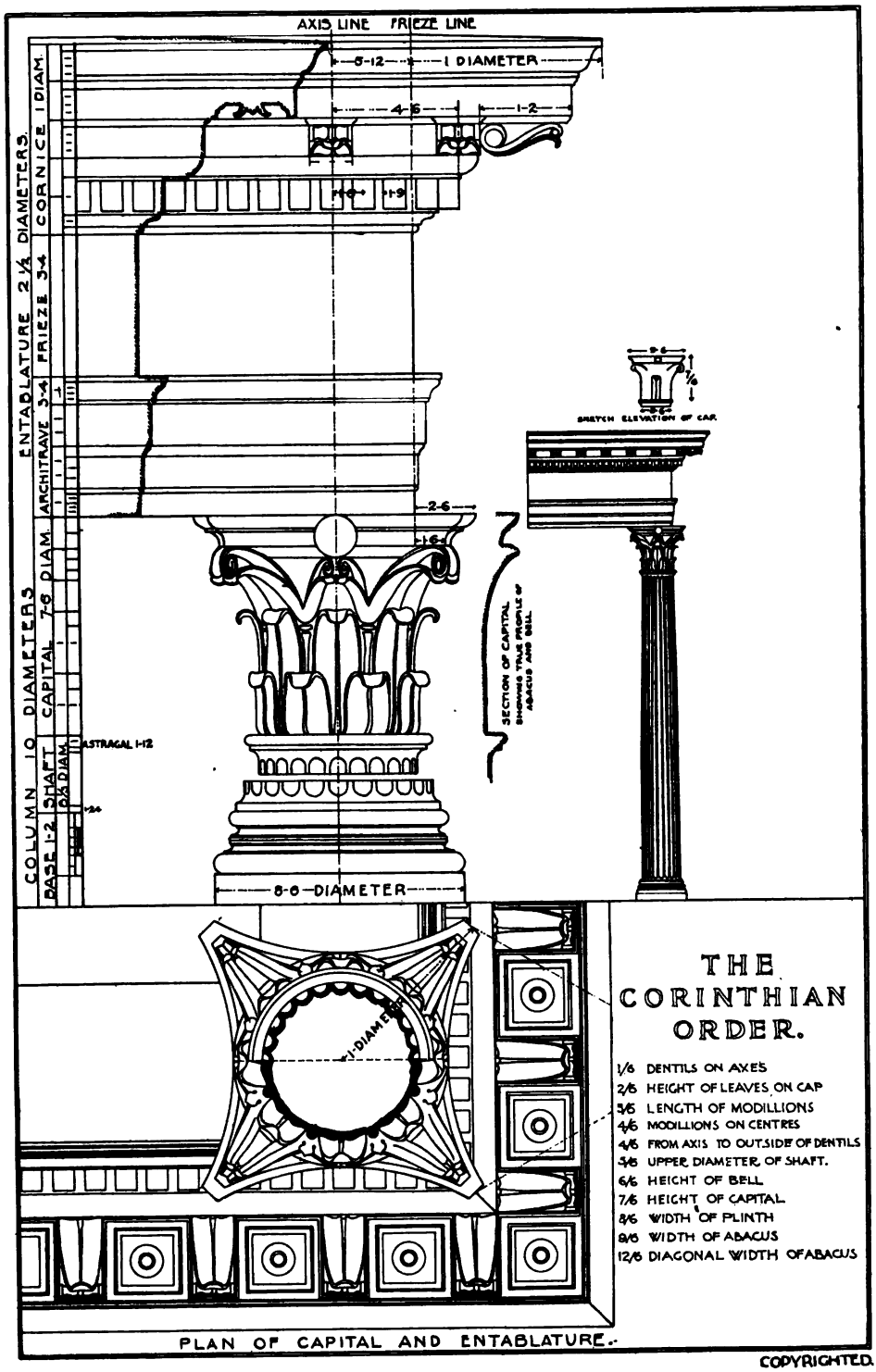


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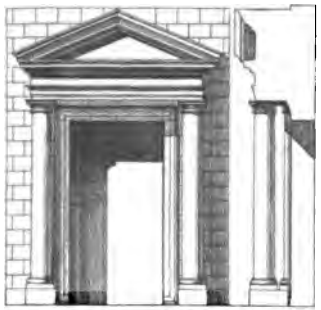
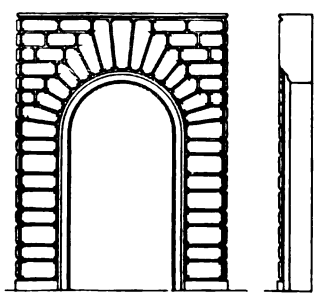
PLATE XIX. DIAGRAM OF THE CORINTHIAN ORDER.

FROM THE BARTOLINI PALACE

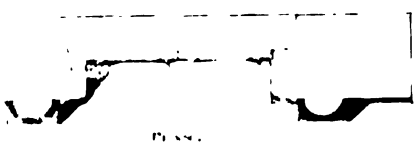


FROM FARNESE PALACE



Door of the Bartolini Palace, Florence.

SECTION



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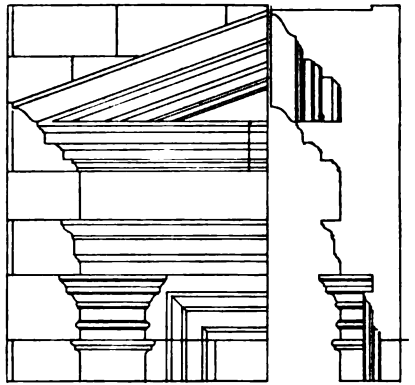


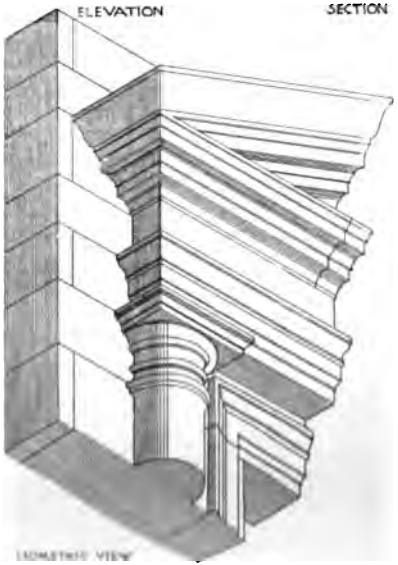


PLATE XX. STUDIES OF DOORWAYS. Second Year.

become familiar objects, and statistical information in regard to them comes as a felt want, and, satisfying a legitimate curiosity, is easily remembered.

Meantime the study of Projections and of Shades and Shadows, which, along with Perspective, Descriptive Geometry and Stereotomy, belong rather to the subject of Graphics than to architectural drawing, is taken up in the first half of the year, and prepares the way for this more scientific treatment of the Orders. It is accordingly practicable to teach not only the forms of these details and the simplest way of drawing them out, but, as has already been said, the shapes of the shades that occur upon them and of the shadows which they cast. For, as the light is supposed always to fall in the same direction, these shapes are always the same. This is a great help toward a draughtsmanship which is at once scholarly and rapid.

To clinch the nail that has thus been driven, and to make sure that the men shall not forget what they have just learned, the work in free-hand drawing is turned into this channel, the class taking photographs or engravings of buildings or parts of buildings in which the Orders occur and sketching them in various aspects.

In the second year the drawings made in the second term are mainly in illustrations of the historical studies, modern or mediæval. But in the first term the time is given partly to work in design and partly to a systematic preparation for it which may properly count as exercises in architectural draughtsmanship. To pass at once from the study of the Orders to problems in the designing buildings, has proved too long a step for men to take without more constant personal supervision than we can offer. For the last two years these disciplinary studies have accordingly been introduced and the drawing of doors, windows, pavilions, external and internal wall treatment, etc., is prepared for by a detailed study of each of these features in plan, section and elevation. Plate XX. This is equally serviceable for the study that it immediately leads to, for the problems in the designing of structures that begin in the third year, and for the historical studies and the work in Historical Design which in both the second and third years occupy the chief part of the spring.

ARRANGEMENT OF COAL WASHING PLANT FOR TREATING BITUMINOUS COALS.

By EDGAR G. TUTTLE, '81

The accompanying drawings show a coal washing plant arranged for treating about 300 tons a day of 10 hours. The design embodies almost all of the requirements likely to be met with in coal washing. The extent of sizing by screens and the washing are designed to treat a coal whose impurities separate with more difficulty than in the case of the presence of impurities as heavy as iron pyrites or heavy slates. For a simpler treatment the plant can be considerably modified. The relative positions of the machines may require to be diffierently arranged under various circumstances connected with the location and depending upon the respective distances and directions at which the coal arrives at the plant and the point at which it is discharged. The main features of the plant can however be carried out to suit the above by making as many right breaks in the lines of machinery as may be necessary to bring the plant in the desired position and connect the points of receiving and delivery with its entering and terminating points. If then the position of any machines is such as not to permit of being driven by the main line shafting, right angle gears can be introduced to transmit power thereto.

In this plant the screening is designed to be done wet. Where the screening is done dry greater fall throughout the line is necessary. Generally where screening is done in the dry way it is accomplished in one large revolving screen or a drum screen consisting of 2 or 3 concentric screens one inside of the other each of a different mesh of perforated metal or wire cloth. Sometimes a shaking screen with several parallel screening surfaces one above the other and each of different mesh are used to produce as many sizes as desired. Where the screening is done dry as above, the jigs should be located more directly below the screen, or that part of the screen from which they receive the sized product.

The treatment of the coal in this plant is as follows: The coal received is that which usually passes through the screens in the chute at the mine tipple. This may be what falls through flat bar screens spaced 1½″ apart or so, or through revolving or shaking screens of somewhat larger mesh. It is assumed that the coal

sent to the washer will not be much larger than 3 inches at its greatest dimension, as all above this will be better hand picked at the tipple and is not readily handled in the size of elevators buckets, that are of sufficient capacity for the greater proportion of the sizes requiring treatment. The coal less than 3 inches in size is then either dumped into the pit *A* from the chute of the mine tipple, if it is located near enough to the washer plant, or else it is unloaded into the pit from R. R. cars. From here the coal is lifted by the elevator *B* to the shaking screen *C*, which has an upper sheet steel screen with 1½″ circular perforations and an under one of ¾″ perforations. The coal is here separated into the following sizes and disposed of as indicated: All greater than 1½″ passes over the screen and is delivered on the picking belt *D*. Coal passing through the 1½″ screen and over the ¾″ screen (size ¾″ to 1½″) falls between the coarse rolls *E* which reduce the coal to ¾″ or less.

The coal passing through the ¾″ perforations of the shaking screen (size 0″–¾″) fall to the foot of the elevator *F*. This coal with that from the rolls reduced to ¾″ or less is lifted by the elevator *F* to the revolving screen *G* at the head of a line of 3 screens which are all 4 feet diameter and about 11 feet long, and of the same construction except that they are covered with screens of different mesh. The screen *G* is divided into 4 sections in the direction of its length and each section is the same width; the first two of which are each covered with sheet iron or steel with ½″ circular perforations and the last two with screens of ¾″ perforations.

The coal passing through the ½″ screen openings (size 0″ to ½″) falls to aprons below, and on each side of the screen which slope into an inclined gutter directly below the screen, and which leads this material (0″ to ½″) into the screen *H* with the water that falls from a spray pipe over the length ot the top of the screen, to wash out particles becoming wedged in the holes and clear the coal from sticking to the sides of the screen. The water is sprayed similarly onto all the screens, and falling through into the gutter, carries the coal passing through the perforations of one screen into the next screen.

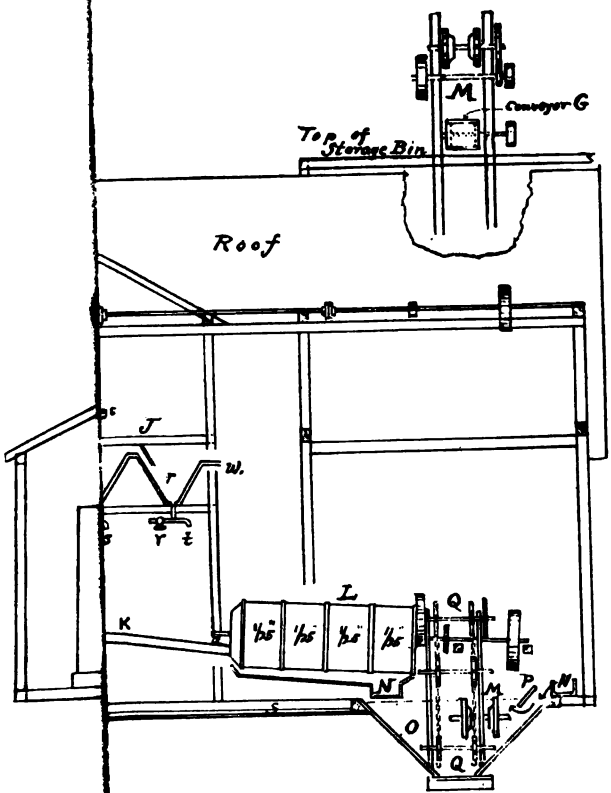
The coal passing through the ¼″ perforations (size ½″ to ¾″) is spouted to the jgs, *a*, *b* .*c* and *d*, which are designed for treating coarse sizes and are provided with crank-arm or slide-yoke motion,

so as as to have a quick down stroke of the plunger and a slow return movement, and speeded to make about 60 strokes a minute of 3″ to 4″ throw, and if a middle product is to be treated they are arranged for drawing this off for retreatment.

If there has been any of the ¾″ to 1½″ coal from the shaking screen that has not been reduced to less than ¾″ by the rolls, then, after this has been elevated and passed into the screen G, it will go over it and out at the end, and will be again fed to the rolls *E* for reduction, and will be then hoisted by the elevator *F* with the coal from the shaking screen as already described. If the rolls *E* do not reduce this amount of coal sufficiently, it can be passed to the rolls *B'* for smaller crushing and treatment with other coal passing through these rolls.

If, however, the coal passing out of the screen *G* is not too large for washing and the impurities are sufficiently unlocked without further reduction, then it may be cleaned completely by washing on jigs treating coarse sizes, or it may be sufficiently cleaned to be used for certain purposes that do not warrant its reduction to smaller sizes, for what further improvement may be thus made possible. In this case the coal, as it passes out of the screen *G*, can be spouted to one or two of the first jigs treating coarse sizes, using for this purpose, say, jigs *b* and *c*, (that is for coal larger than ¾″), and jigs *a* and *d* for the sizes ½″ to ¾″, or such proportion of these or other jigs as may be necessary for the quantity of these sizes produced.

Although a preliminary examination and test of the coal will determine the quantity of each size of the larger sizes of coal, and the number of jigs required to treat it, it is advisable in designing the jigs and arranging them, in the plant, to provide for possibilities of treating larger sizes on some of the jigs intended to treat smaller sizes, or the reverse. The points to be considered in this connection are: 1. Designing jigs so that the length of the stroke and the number per minute can be readily increased or diminished to suit the sizes treated. 2. Locating the jigs under the screens so that the material likely to be received from one or more points of the same can be readily spouted to the jigs with changes in sizes to be treated thereon. 3. Arranging the jigs so that the washed product and the refuse discharged therefrom can be readily delivered to the points desired, which may vary with the sizes produced on account of possible difference in the quality of different sizes.



T.

4. In case a middle product results requiring treatment, the jigs should be arranged and handily located so that these can be drawn off and discharged to rolls for reduction, or else be handy to an elevator to lift this product to rolls intended for this purpose, or for smaller crushing.

The 0″ to ½″ coal carried into screen *H* is separated into sizes as follows: Size 0″ to ¼″ is screened through the first 2 sections with ¼″ holes, and is caught by the aprons and gutter below the screen and spouted into the screen *I*. The coal passing over the first 2 sections of screen *H* will be ¼″ to ½″ in size. This passes onto the last 2 sections of screen *H* with ⅜″ perforations which separates it into 2 sizes, as follows: First, coal passing through the ⅜″ holes (¼″–⅜″) which is spouted to jigs *i* and *l*. Second, coal passing over and out of the end of this screen (⅜″–½″) which is spouted to jigs *e*, *f*, *g* and *h*.

The coal spouted from the gutter under the screen *H* into screen *I* (0″–¼″) is separated as follows: The coal passing through the first 2 sections of this screen with $\frac{1}{16}$ holes (size 0″ to $\frac{1}{16}$), falls into the gutter below it, and if sufficiently pure need not be treated, but can be spouted directly into the sluice boxes carrying washed coal from the jigs. If, however, it contains impurities and there is a considerable quantity of this size it will require treatment. Generally it will suffice to spout this coal into the jigs *n* and *o* arranged for treating this size and in the jigging thereof most of the overflow will be pure coal with possibly some light mud which will subsequently pass off in the water overflowing from the settling tank where the fine coal will be treated for its deposition from suspension in the water from the jigs. If, however, the impurities separate with difficulty, this material 0″ to $\frac{1}{16}$″ will be carried along in the gutter under the screen I to the Hydraulic Classifier J for treatment as will be described.

The coal, $\frac{1}{16}$″ to ¼″, passing onto the last two sections of the screen *I* with ⅛″ holes, is separated as follows: That passing through these screen sections ($\frac{1}{16}$″ to $\frac{1}{8}$″) is spouted to jigs *m* and *p*. The coal passing out of the end of this screen is sized ⅛″ to ¼″, and is spouted to jigs *j* and *k*.

The coal is spouted from screens to the jigs through troughs 6″ square or so inside, lined with No. 12 or 14 sheet iron. Sometimes storage boxes are introduced below the screens to hold the sized screenings, from whence it is spouted to the jigs. These;

however, in wet screenings are apt to clog up, and are not as satisfactory a means of insuring a steady supply to the jigs as in arranging a regular feed to the elevator *B*, and by keeping a sufficient supply of raw coal always on hand in the pit *A*.

The jigs *a*, *b*, *c* and *d* are of one compartment about three feet square, and, as mentioned, are arranged to draw off a middle product, that is material on the jig bed from a horizon between the top layer of washed coal and the bottom layers of slate. Where impurities occur with coal in the form of small particles, or closely adhering to the coal, this product is apt to occur among the larger sizes of coal; or it may consist of particles of coal of an inferior quality, or of bony coal, and being intermediate in specific gravity between the lighter coal at the top of the bed and the slate or impurities on the bottom of the jig bed, this middle product will occur in a layer midway between the two, where it may be drawn off in jigs arranged for the purpose. The remaining jigs are of two compartments, each compartment being 24″ x 32″. These jigs are speeded at 100 to 180 revolutions, or double strokes, per minute, and with throws of 2½″ for the larger sizes to ¼″ for the smallest sizes.

If the impurities are with difficulty separated from the coal in the smaller sizes it may be necessary to have three compartments instead of two in the jigs *m*, *n*, *o* and *p*, so that the material will travel over a greater length of jig bed in being treated, thus allowing more time to effect their separation.

The coal after being washed passes out of the jigs at the overflow into the trough *K*, and is carried by the water from the jigs to the drainage screen *L*, which is preferably covered with sheet copper of $\frac{1}{25}$″ perforations, where the water is removed and all coal larger than $\frac{1}{25}$″ passes over the screen and out at the end to the elevator *M*, whence it is raised high enough for discharging either into bins, or else to a point for loading.

Jigs may be used in which the water does not flow therefrom, and the coal is removed from them by elevators with perforated buckets, or, the coal overflowing with water from the jigs may have the water drained therefrom by passing over screens forming the overflow chute. In this case there must be sufficient fall if the coal is to be chuted dry from the jigs to the elevator M, or else the jigs may have less inclination or all be located on the same level, provided conveyors are introduced to convey all the coal from the jigs to the foot of the elevator *M*.

Where coal is to be stored in bins of considerable extent a conveyor G' is arranged at the top of the bins, onto which the coal from the elevator is delivered. The conveyor travels the length of the bins near their center line, and is so designed that, by means of openings in the bottom of the conveyor box, they can be opened or closed as desired and the discharge of the coal into the bin from any point thereof thus effected, permitting of an even distribution of coal in the bin. The buckets of the elevators M are perforated so as to drain as much of the water from the coal as possible. The water and coal less than $\frac{1}{2}\frac{1}{5}''$ in size, passing through the drainage screen L fall upon an apron and into a gutter, from which it flows by the trough N to the settling tank O. The trough N leads to one side of the settling tank, and by means of little adjustable openings along the length of one side of this trough the discharge of the water with the fine particles of coal into the settling tank can be regulated so as to be evenly distributed, which is important to secure effective settling. The water and fine coal are discharged into the settling tank on one side of a partition P, which extends the length of the tank, and its bottom is 3 or 4 inches below the surface of the water. This causes the water flowing into the tank to move firstly in a downward current, and then across the tank as an even, slowly-moving body of water towards the discharge side. Surface currents are thus prevented, which would otherwise occur, and carry the material over the surfaces and out at the discharge without settling.

The settling tank is 12 feet wide and 32 feet long and 4 or 5 feet deep at center with sides sufficiently inclined so that particles will not settle thereon.

The suspended coal of sand and slime sizes are thus settled, and by means of a slowly moving drag Q with pedals or scrapers 4 feet apart, the settlings are moved gently along and finally scraped up an incline and out of the tank and dropped off at the end of the drag which delivers the settlings at a point where they will fall and mix with the coal from the discharge end of the drainage screen L and both be taken up together by the elevator M.

The water overflowing from the settling tank with what suspended matter it may still contain, which will be very small, overflows into the trough R. It is important that this overflow be truly level so that the water from the settling tank will overflow in an even sheet, thus insuring a slowly moving current through the settling tank.

From the overflow trough R the water flows into the trough S to the sump T, from which it is lifted by the centrifugal pump U and delivered through pipes or launder boxes to screens and jigs treating the smaller sizes.

Any overflow water from this sump passes to the sump Z.

The refuse, impurities, slate, etc., drawn off from the jigs as well as the material settling through the sieves of the jig bed and released at the bottom or mud discharge, are all conveyed with the water escaping therefrom by the slate troughs to the pit V. These troughs are more highly inclined for the large sized slates to facilitate their movement to the pit V. The slate troughs are best located on the floor near the base of the jigs or else below the floor line, with the flooring from all the jigs sloping thereto so as to drain off all water escaping or leaking from jigs, pipes, troughs, etc., and thus keeping the floors clean. The slate troughs are usually made 4″ to 6″ square lined with No. 12 or 14 sheet iron curved at the bottom. The amount of water escaping with the refuse is comparatively small to that flowing with the washed coal from the jigs. The pit V need therefore not be very large. The one here shown is 8 feet square at top, with side sloping about 50° and 3 to 3½ feet deep.

The refuse is removed from the pit V by the elevator W with perforated buckets to drain off the water taken up by them with the material. The refuse is discharged at the elevator head into the storage bin X for removal by R. R. or dump cars or otherwise.

If the location of the plant is on an elevation where there is considerable low land that can be filled, then the refuse, escaping with water from the jigs treating the smaller sizes can be carried in troughs with a grade of ½ or 1 foot fall per 100 feet to such points where the refuse can be disposed of to make fills. If there is sufficient fall the refuse from the jigs treating coarser material can be likewise disposed of in troughs of steeper grade, viz., 2% to 4 % fall.

If there is only sufficient fall for disposing of the smaller sized refuse as above, then the heavier or larger sized refuse may have to be removed by the elevator W and disposed of as indicated.

The water, after the refuse has been settled therefrom into the pit V overflows into the trough Y and flows to the sump Z, from which it is lifted by the centrifugal pump A' and is delivered through pipes or water troughs to the jigs, treating the coarse sizes, and the rolls.

The middle product drawn off of jigs *a*, *b*, *c* and *d* is spouted to the rolls *B'* and reduced from ½″ or ¾″ to about ⅜″ downward, depending upon how small it is found necessary to reduce the middle product to unlock the impurities. This material is then lifted by the elevator *C'* high enough to be discharged into the revolving screen *H* and there treated with the sizes of coal discharged into this screen from the screen *G*. This is the case if the middle product has been reduced to sizes small enough to be sized in the screen *H*. If it is not necessary to reduce all the middle product to sizes smaller than those treated in screen *G*, then it is lifted by the elevator *C'* only high enough to be discharged into the elevator *F* and from there it is handled as usual with the other coal lifted by this elevator.

The coal that passes over the 1½″ perforations of the shaking screen *C*, which will be from 1½″ to 3″ or so in size, is delivered onto the travelling picking band or belt *D*, where it is hand-picked by as many men or boys located along both sides of the belt as may be required to thoroughly clean the coal as it is conveyed toward the storage bin *D'*, where it is dumped for loading on R. R. cars. This belt is 3 or 4 feet wide and about 40 feet long, and has a slow travel of about thirty feet a minute. It is either composed of sections of wood or iron 3″ to 6″ wide by 3 or 4 feet long, whose ends are fastened to sprocket, or link-chains. The sections of wood or iron are either bevelled, jointed, grooved or hinged, so as to lay close to each other and form a flexible band, readily curving around the sprocket wheels of the driving gear. If these sections are of iron they generally lap each other where their sides come in contact, and form a sort of hinge joint.

If the coal treated on the picking band is of large sizes, requiring sledging and slabbing, so that it is broken up in cleaning, and considerable small coal results; then the sections or slats of the picking band are sometimes separated slightly from each other so as to act somewhat like a screen and allow the small coal produced to fall through and thus separate it from the large lumps in loading. The impurities picked from the coal traveling on the band which may contain more or less coal are dropped into chutes leading to the pit *E'* or else are thrown into this pit, and from here are lifted by the elevator *F'* back into the washer building and high enough to be discharged on the rolls *E* for reduction and delivery to the to the elevator *F* for the usual treatment in the plant.

If there is much refuse picked from the lump coal at the mine tipple, and it has considerable good coal adhering to it, it can be broken by sledging, or a special crusher may be erected for reducing it, after which it is discharged into the pit *E'* and lifted by its elevator for treatment in the plant with other coal from the pit.

If this waste removed at the mine tipple is not too large, and the tipple is near the washer plant, it may be chuted directly to the rolls *E*. If the tipple is located at some distance and this refuse is to be treated it will be necessary to bring it there by R. R. or dump cars or a conveyor if the distance is not too great.

If the amount of coal requiring hand picking is large, it may be necessary to introduce 2 picking belts. This is generally preferable to increasing the length of the belt with increased quantity to be treated. The maximum length for a picking belt should be 30 to 50 feet.

If the impurities in the sizes ¾″ to 1½″, separated on the shaking screen, do not adhere to the coal, and are readily hand-picked, they need not be reduced in the rolls, as mentioned, but can be discharged onto a second picking belt that may be introduced for treating these sizes similarly as explained for the 1½″ to 3″ sizes. These may be delivered into bins if to be loaded for shipment or the picking belt on which they are treated may have such a direction of travel as to finally discharge them to the foot of elevator *M* for removal with the other coal hoisted by this elevator. Or, if the impurities are in considerable quantity in the ¾″ to 1½″ sizes, these may be removed by washing, if they do not adhere to the coal so as to require crushing to liberate them. This size may then be dropped from the shaking screen with the 0″ to ¾″ size and hoisted with it by the elevator *F* to the screen *G* without first passing through the rolls *E*. In this case, this sized coal will, as previously explained, pass over the screen *G* and out at the end, sized ¾″ to 1½″, and fall onto two of the jigs *b* and *c*, or others as may be required for treating it.

TREATMENT OF THE 0″ TO $\frac{1}{16}$″ SIZES.—HYDRAULIC CLASSIFIER.

The hydraulic classifier consists of a box of two or more compartments with inclined sizes, from two feet or more in width, and of such length as is determined by the number of classes of sizes it is intended to produce. The sides are sloping, for proper discharge of the materials settled therein from the bottom, and fitted

sometimes with piping, as will be described. A partition, extending 2″ or 4″ into the water of the classifier, extends across its width so as to deflect the inflow of water and direct its current downward, thus preventing surface currents.

The treatment of 0″ to $\frac{1}{16}$″ size flowing from the gutter under screen *I* to the classifier is as follows:

With the dimunution of the velocity of the current of water flowing from the narrow channel of the gutter into the wider channel of the classifier, there will be deposited in the first compartment *q*, of the apparatus, such smaller sizes of the heavy impurities and such larger sizes of the lighter coal as are equally settling. Likewise in the second compartment *r*, there will be a settling of relatively smaller sizes.

It will depend considerably upon the nature of the impurites and coal in these smaller sizes as to what the treatment will be.

The proper method of treating material classified as above, is to submit it to treatment with water on machines of the type of the inclined table, or shaking or bumping tables, where the larger specifically lighter particles of coal will be moved further down the plane by the water than the smaller specifically heavier particles of slate or impurities.

In coal washing, however, the cost of this treatment is too great, and the small sized material is usually in too small a quantity and of insufficient value to warrant the expense of the treatment, or the coal may be sufficiently rich not to require treatment.

The trough washer is a machine, nearest approaching the types above mentioned, that it is advisable to incur the expense of, although the treatment of the coal therein is not perfect. This is used for sizes up to 1½″ or so in rough washing, but is better adapted for the smaller sands and slime sizes or the products of the hydraulic classifier in question.

The trough washer consists of a trough inclined 1 in 12, 40 to 60 feet long and 1 or 2 feet wide at bottom and sides sloping 50° to 60°. In this a scraper chain works, with scraper 4″ to 6″ deep and 6 feet apart closely fitting the bottom of the trough and moving slowly up the incline. The fine coal is fed into the trough midway between the 2 ends and 60 to 150 gallons of water a minute are fed into the trough at the upper end. The action of the water is to wash the coal down the trough and over the tops of the scrapers, while the heavier impurities settle to the bottom and

are moved up the trough by the scrapers and discharged over the top.

The coal discharged at the lower end of the trough with the water is drained over a screen and the water thus separated and re-used, but preferably it can be discharged into the settling tank *O*, and there removed by the drag where this fine coal can be handled and used better when mixed with coarser coal.

Generally, however, a separation of the impurities from the classified products of the 2 compartments of the hydraulic classifier can be effected, that will be sufficiently satisfactory where the quantities are small, by allowing the settlings in the compartment *q* to pass out of the spigot *s* to the jig *n*, and that from *r* flowing from the spigot *t* to pass to the jig *o*, where in rapid jigging somewhat of a separation is effected if the strokes of the jig last only during the period of accelerated velocity of fall of the particles. In this case the larger lighter weight particles of coal require a longer time before arriving at their maximum velocity of uniform motion than the smaller heavier particles of impurities. So that with strokes of the jig applied to last for $\frac{1}{8}$ or $\frac{1}{12}$ of a second or so, particles of coal and slate that are equally settling in the classifier may be separated to some extent on the jigs, the coal being maintained at the top of the bed and the slate settling to the bottom as usual.

If there is only a slight difference between the specific gravity of the coal and slate, it may be advisable to make the smallest size treated on the jigs from the screens $\frac{1}{25}''$ or $\frac{1}{32}''$. In this case the $\frac{1}{16}''$ screen should be replaced by a $\frac{1}{25}''$ or $\frac{1}{32}''$ copper screen of perforated metal or wire cloth. In this case the largest size treated by the classifier will be $\frac{1}{25}''$ or $\frac{1}{32}''$.

The use of small screens should be avoided, however, if possible, as their life is short and the value of the material rarely warrants the expense.

The classifier is arranged so that the discharge can be made continuous from the bottom by the spigots *s* and *t* for drawing off the particles and what water escapes therewith. The velocity of the water travelling across the classifier from the receiving to the discharge end, can be reduced according to the amount of water fed onto the classifier, and the amount drawn off at the bottom flow.

If it is found necessary to prevent a settling of too small sizes in the first or second compartments of the classifier, and at the same time effect somewhat of a separation, an inflow of clear water can

be arranged, which is admitted by the pipes at the bottom and regulated by the valves *u* and *v*. This inflow is through pipes of larger area than the outflow through the spigots *s* and *t*, and the velocity of the inflow is not so great but what it will allow the particles of the sizes desired to settle down through its current and escape by the spigots *s* and *t*. This ascending current may have to be varied from 0.4″ to 3″ a second, so that an inlet pipe of 1½″, 2″ or 3″ may be necessary. The larger the better to provide for increasing or decreasing the sizes of the classified product desired.

A separation of the limits of sizes desired can be thus effected by maintaining just sufficient upward current so that the smaller sizes will not be permitted to settle, but the larger ones will be allowed to fall through the current and be discharged by the spigots *s* and *t*, which can be plugged with reducers to ¼″ or ¾″, as may be required to regulate the outflow, which will depend upon the rapidity with which the larger sizes accumulate.

By testing the products under various flows of inlet and discharge currents it will be determined what conditions can be produced, and according to which the product can be best treated.

It may occur that the discharges from *s* and *t*, under an upward current, are entirely impurities, and the overflow at *w* is entirely pure coal, in which case the coal can be run directly in with other washed coal to the settling tank. If this should contain much mud or small thin disks or plates of impurities, it may be possible to have these pass off as suspended matter in the overflow from the settling tank.

If, however, the tendency of this form of impurities is to settle in the settling tank, they may be separated in the classifier by regulating the flows of water so that they will be carried out over the overflow thereof.

If the light-weight impurities can be thus disposed of, and if it is possible to regulate the lower inflow so as to have the heavier impurities only discharged from the spigots *s* and *t*, then the coal may be separated therefrom and maintained in the classifier midway between the bottom discharges and the overflow.

In this case there should be 2 sets of hydraulic classifiers so that the current of water from the gutter under the last screen can be turned to a second classifier when the first has become filled. The first can then be cleaned out by allowing the impurities to discharge

at the spigots until the coal begins to flow. Then the washed coal can be spouted to the washed coal trough or to the settling tank. When the classifier is emptied it will then be in readiness for use when the second classifier has become filled.

If the impurities are all light weight they may be separated from the coal by adjusting the amount of the bottom discharge, or, if necessary, of the inlet current to such a point that the coal will be discharged from the bottom, while the impurities pass to the overflow *w*.

In all these adjustments to regulate the amount of water admitted to the classifier, or to form an upward current, or of the amount allowed to discharge, the resulting current in compartment *r* should be somewhat diminished from what it is in compartment *q*, in order to allow a settling of the particles in compartment *r*, which are smaller than those settling in compartment *q*. If the particles treated are very small and very light weight, it is advisable to make the compartment *r* wider than compartment *q*, to insure a diminution of the velocity of current necessary.

SPEEDING AND GEARING OF MACHINES.

	Size of Pulley on Main Line Shaft 125 Rpm.	Pulley (1) On Machine.		Pinion (2) on Same Shaft as Pulley (1).		Spur (3) Driven by Pinion (2).			Machine.	
		Size.	Rpm	Width.	Dia.	Width.	Dia.	Rpm	Diameter.	Traveling Speed per Minute.
Rolls	10″×52″	10″×48″	133	4″	8″	4″	36″	30	Rolls=19⅛″	155 ft.
Large Elevator. B F M	8″×28″	8″×34″	103	4″	5¼″	4″	36½	14.9	Sprocket=30″	115 "
Small Elevators	6″×18″	6″×24″	93.7	2″	6″	2″	2 ft	23.4	Sprocket=18″	109 "
Revolving Screen	8″×2′9″	8″×48″	88	2″	6″	2″	2 ft.	22	Screen=4 ft.	272 "
Picking Belt	6″×9″	6″×36″	31¼	4″	6″	4″	3 ft.	5.2	Sprocket=2 ft.	32.2 "
Drag	6″×6″	6″×36″	21	2″	6″	2″	24″	5.2	Sprocket=2 ft.	32.2 "
Centrifugal Pump	6″×36″	6″×6″	750							
Shaking Screen	8″×24″	8″×30″	100							4″ stroke
Crank Arm Jig	4″×9″	4″×8″	60							4″ "
Conveyer G	6″×18″ 103 Rpm.	6″×24″	77¼	2″	6″	2″	24″	19¼	Sprocket=24″	121 ft.

WATER REQUIRED IN PLANT.

Clear Water.

		cu. ft.
4 Revolving Screens	1 cu. ft. a min.,— 4.0 cu. ft.	
2 Rolls	1 " " " " — 2.0 " "	
4 Jigs (sand and slime sizes),	4 " " " " —16.0 " "	
Classifier	2 " " " " — 2.0 " "	
Total, raised 45 ft.—180 gals.—	2.40 " "	24.0

Reused Water.

2 Jigs—	⅛–¼ sizes,	4 cu. ft a min.,—	8.0 cu. ft.	
2 "	¼–⅜ "	5 " " " " —10.0 " "		
4 "	⅜–½ "	5 " " " " —20.0 " "		
4 "	½–¾ "	6 " " " " —24.0 " "		
	Total raised 24 ft.—465 gals—	62.0 " "		62.0
	Total fresh and muddy water—645 gals.—			86.0

Horse Power Required.

For Jigs Number of Jigs	Size Treated	H. P. per Jig	Total H. P.	Horse Power each	Horse Power Total
2.	0–$\frac{1}{16}$	1	2		
2.	$\frac{1}{16}$–⅛	1	2		
2.	⅛–¼	1¼	2.5		
2.	¼–⅜	1¼	2.5		
4.	⅜–½	1¼	5.0		
4.	½–¾	1½	6.0		
			20.0		20.0
1 Shaking Screen					2.5
1 Course Rolls.					8.0
1 Fine Rolls					3.0
1 Picking Belt.					2.0
2 Revolving Screens 4′ dia. 11′ long				2.5	5.0
2 " " " "				1.5	3.0
1 Drag for Settling Tank					1.5
1 Centrifugal Pump 180 gals. 45 ft. 3″ suction 2″ discharge					4.5
1 " " 645 gals. 24 ft. 5″ suction, 4″ discharge					7.5
1 Conveyor					2.0
1 Elevator, 400 tons, 10 hrs. 42′ ft lift					2.5
1 " 300+ " 10 " 40 " "					2.0
1 " 300 " 10 " 60 " "					2.4
1 Small Elevator 60 tons 10 hours 36 ft. lift (Middle Product)					1.0
1 " " — " " " 26 " " (Refuse)					1.0
1 " " — " " " 30 " " (Pickings)					1.0
Total Horse Power					68.9
Add 15% for friction					10.0
Total					78.9

About an 85 Horse Power Engine and a 100 Horse Power Boiler will therefore be required.

Crushing Rolls.

The coarse rolls are 18″ wide and 19½″ dia. and corrugated horizontally. They make 30 Rpm., or have a tangential speed of about 155 feet, and break about 30 tons to ½″ sizes or 70 tons to 1″ sizes in 10 hours. If a greater amount of the larger size are

to be reduced than above, larger rolls or two of the above size are necessary.

If the coal sticks to the rolls, as it will if clayey slate is present, it is preferable to use tooth rolls, or these should be used if the coal is very friable and apt to become reduced to too small sizes. Toothed rolls have a somewhat higher speed at the periphery, generally about 400 to 800 ft. a minute.

One of the rolls of a pair is in a movable box connected with rods to a steel or rubber springs so as to allow the rolls to yield in case of hard pieces or iron, etc., getting between the rolls that would otherwise break them.

A spray of water is fed into the top of the rolls to keep them clear of adhering particles.

Steel brushes are also arranged back of the rolls to scrape against them and remove particles becoming wedged between the corrugations or teeth.

Fine Crushing Rolls.

The fine rolls need only be about 14″ dia. and 12″, but it is preferable to have them as large as the coarse rolls, in the event of it being desired to change the grading of the crushing throughout the plant.

Revolving Sizing Screens.

These are 4′ dia. and about 11 feet long. The surface of the screen is divided into 4 sections by 5 spiders, keyed or set screwed to a $2\frac{15}{16}$″ shaft. Each section is covered with perforated sheet metal, requiring 4 sheet 32″x39″ to cover each section.

The screens have a slope of 8″ to 12″ in their entire length. The shaft being laid inclined.

The sections of sheet metal may be either rivetted or fastened by bands to the spiders. The latter method being preferable for dispatch in case of repairs.

Conical screens may be used, in which case the shaft is laid level. The slope of the sides being sufficient to assist the passing of the material through it. The shape of the screen sections in this case may give more trouble in case of repairs than with cylindrical screens.

The speed of screens is about 22 Rpm. or the peripheral speed will be about 270 feet a minute.

Sprinkling Screens.

The screens are sprinkled by a spray of water from a 1½″ pipe located above the screens and having ⅛″ holes every inch or so on the under side of the pipe.

Capacity of Revolving Screens.

Size of screen perforation.	Number of sq. ft. of screening surface required per ton in 10 hours.
1½″–2″	·32
1″ –1½″	·43
¾″–1″	·72
⅜″– ¾″	3·70
⅛″– ⅜″	5·4
0″ – ⅛″	18.0

The above capacity is variable depending upon the amount of other sizes mixed with the sizes to be screened.

Shaking or flat screens have greater capacity than revolving screens.

Shaking or flat screens are preferable where they are not to be erected too high on the structure, where they cause jarring to the building.

Elevators.

Large elevators are best arranged when buckets are mounted on double chain formed of 12″ or 15″ links connected with rods onto which the links on either side of the elevator buckets are bolted. The buckets are bolted to two straps hinged from one rod to the other.

The elevator frame is constructed of wood with guides on either side which may be covered with strap iron on which the elevator rods slide in the upward movement of the elevator, or the guides may have angle iron sliding pieces, in which case the links slide therein and are guided by them.

The sides of elevator bucket should be of No. 14 Otis steel, and the front of No. 12 steel, with ribs at the top, front and sides.

Their shape should be somewhat rounded at bottom to prevent material becoming wedged therein, but not too rounded, or where they discharge at the elevator head, the material may fall on the back of the bucket below it and inside of the elevator frame.

The elevators should be as far from the vertical as possible for the most perfect discharge at the elevator head, otherwise it may be necessary to introduce special devices for perfecting the discharge.

The usual travel for an elevator is about 100 to 150 ft. a minute, although where they are vertical or nearly so a speed of 200 or 225 ft. a minute may be necessary to insure proper discharge. The slower the speed the less the wear on the elevator.

Small elevators may be mounted on small sprocket chain or link belting with small cast or malleable iron buckets. Their speed may be 150 to 200 ft. a minute or less.

The chains supporting the elevators may be operated by sprocket wheels or hexagonal or octagonal drums driven by a pulley with gearing.

Either the upper or lower set of sprocket wheels or drums should be in an adjustable boxing, which will permit of moving the bearing of the sprockets by screws so as to tighten up the elevator chain as it becomes worn.

JIGS.

They are preferably built of wood, as they require less expensive foundations, and although requiring more frequent repairs than iron jigs, they are moderate in first cost, and wearing parts in iron jigs being more expensively replaced than in wood jigs, the cost of repairs in the end is not much greater in wood than in iron jigs.

COARSE JIGS.

Jigs treating large sizes have one compartment about 3 ft. square and the stroke is given by a crank arm movement making 60–3″ or 4″ strokes per minute.

The depth of the jig frame should be about 10″ at least, below the overflow. The jig frame may consist of an iron bar grating, or of copper cloth or perforated metal of about 8 mesh.

The discharge for the lower product should be as automatic as possible and should preferably extend across the width of the bed.

The coarse jigs should be arranged for treating the middle product, and its discharge should also be constructed as above.

Fine Jigs.

These should have 2 compartments and rarely 3 are necessary. Each compartment is about 24″ wide and 32″ long. These are provided with double adjustable eccentries so that the length of the stroke can be varied as desired. These make 100 to 180 strokes per minute of 2½″ to ¼″ throw each.

The depth of the jig frame at the final overflow should be about 7 inches below it.

It is also desirable that the discharge for the lower product or slate should be automatic and arranged across the width of the jig beds, especially for the larger sizes, although the refuse in this size material can be readily withdrawn by a small slate box 3″ or 4″ square, located at the side of the jig and the slate tapped at about 2″ above the level of the jig frame.

The jig frame is of wood, built of ½″ by 2½″ slats with abou 2½″ square openings. The width and length of the frame is about ½″ less each way than the space they occupy in the jig.

Side plunger jigs are preferable to facilitate repairs, although there is more lost motion in these than in jigs with under pistons or jigs in which the jigging is done on a movable bed.

To facilitate determinations of speeding jigs it is preferable to have the plungers and the jig beds of the same area.

The bottoms of the jigs should all be steeply sloping to one or more mud discharges, and the slope sufficiently steep and the mud valve regularly opened to prevent material clogging up the jig bottoms.

Feldspar Bed.

The jigs treating material from ⅜″ downward have sometimes a bed of feldspar through which the jigging is done. The feldspar is of such size that the particles of coal and impurities will not fall through its interstices. The mesh of the jig sieve need then only be large enough to support the feldspar.

Capacity of Jigs.

An average estimate of the capacity of jigs is 1 ton for each inch in width per 10 hours. This is independent of the length of the jig.

A safe low estimate to provide against irregularities in the supply of coal is as follows :

Jigs treating sizes from, to	Capacity in tons in 10 hours per inch in width	Width of Jig	Capacity in 10 hours
0″—$\frac{1}{16}$″	.3	24	7 tons
$\frac{1}{16}$—⅛	.41	24	10 "
⅛—¼	.6	24	14 "
¼—⅜	.84	24	20 "
⅜—½	1.00	24	24 "
½—¾	.83—1.2	36	30–43 "

SPEED AND STROKE OF JIGS.—FOR DIFFERENT SIZES.

Size of Coal.	Revolutions of Jig per Minute.	Length of Stroke.	Mesh of Wire Cloth of Jig Sieve.	Pulley on Jig.	Driving Pulley on Main Shaft.
2″—3″	50—60	5¼	1¼ inch.		
1½—2	50—60	4 to 5	1 "		
1 —1½	60—90	3 to 4	½—⅞ "		
¾—1¼	100	2 to 3	6×6	20″	16″—18″
½—¾	110	2¼	8×8	"	18
¼—⅜	120	2	10×10	"	20
⅛—¼	130	1½	10×10	"	22
$\frac{1}{16}$—⅛	140	⅝—1	16×16	"	24
$\frac{1}{50}$—$\frac{1}{16}$	150	⅜—¾	20×20	"	24
0—$\frac{1}{50}$	180	¼	30×30	"	28

PICKING BANDS OR BELTS.

These are generally 4 ft. wide and travel at a speed of 30 to 60 ft. a minute. For sizes from 1½″ up, and in quantities of 30 tons per hour, belts should be 15 ft. long plus 10 ft. more in length for each 3% of material picked out.

For sizes from ¾″ to 1½″ the belt should travel at the rate of 30 ft. a minute, and for every 20 tons an hour, 15 ft. length of belt is required for each 1½% of material picked out.

If these sizes contain more than 4 or 6% of impurities it is generally preferable to treat them by washing.

DRAINAGE SCREEN.

This is covered with No. 10 sheet metal, preferably copper, to avoid rapid wear which will occur with thin sheet iron or steel if

water is acid. This screen is geared the same as the other revolving screens.

Settling Tank Drag.

This is arranged with wooden pedals about 2″ thick, 4″ to 6″ deep and 2 or 3 ft. long, attached to lugs on 6″ links every 4 ft. and geared as shown, to move slowly in the bottom of the tank and not rile up the settlings too much. The bottom and sides of these pedals have pieces of rubber or leather fastened to them, so as to keep closely in contact with the bottom of the tank along its bottom and when mounting the incline.

Shafting.

The main shafting is $2\frac{5}{16}$″ dia. driven at 125 Rpm. It is desirable, if possible, to avoid any shafting at right angles to the main lines of shafting, which will require transmission of power by bevel gears, although this cannot always be avoided.

Engine.

About an 85 H. P. engine will be required for the size of plant shown to have a safe allowance of power. This should be mounted with a 10″ shaft and a 16″ × 52″ driving pulley. The engine should be located so as to be as near the machinery as possible and thus reduce strain on the shafting.

Boiler.

About an 100 H. P. boiler or 2 boilers of 50 H. P. each should be provided for furnishing the power required, with a safe reserve of power. The boiler should be located handy to a point where the coal is dumped for receiving its supply. This may be near either where the raw coal or the washed coal can be had.

Location of Plant.

The arrangement of the plant can be carried out if the location is on level ground or on a hillside. Unless the material arrives at the plant from a higher elevation there is no preference in one location over the other.

A hillside location permits of attaining the proper grades for lines of screens, jigs and other machinery nearer the natural ground. It may not be necessary to support as much of the machinery in the building as on a level location, nor require as many elevators.

But the building will be longer, and the increased number of floors requiring more labor for proper attention to machinery does not make a hillside location more preferable, whether its first cost is more or less than a level location.

It is important that the floor of the building and bottom of the pits be located above the general level of ground so that they can be readily drained when desired.

Construction of Building.

Generally a frame building on stone foundations will answer all purposes, especially if there is no danger in case of fire, or if the screening is done wet, and heavy machinery is not supported high in the building.

In case of fire or if the expense is warranted an iron frame building covered with corrugated iron is preferable.

If there is much heavy machinery supported in the structure the the walls up to that height should be of stone or brick, and balance of wood or iron.

Light.

It is essential that the location of the machinery and especially the jigs be such that the building can be constructed to allow light to fall upon them. For this purpose the jigs and such machinery should be located near the outer walls of the building which will have windows in the sides or if the jigs are located inside, no machinery should be above them that will prevent the access of light thereto from windows in the roof.

Cost of Plant.

Excavation—500 cu. yds. @ 20 c.	$ 100
Foundations—Stonework, Building 150 cu. yds @ $1.50	225
Stonework of Washer Machinery and Pits, 70 cu. yds. @ $2.00	140
Boiler and Engine Foundation and Walls	500
Washer Building—Lumber, 80,000 ft. B. M. @ $10.00	800
Other Finishing Lumber, Doors and Windows	300
Carpenter Work	1,200
Iron Work	300
Coal Washing Machinery	10,000
Erecting (Machinist Labor)	1,200
Freight, Teaming	800
	$15,565

The cost of the plant will vary considerably, according to location and distance of source of supplies. The above will be the cost where material, machinery and labor can be conveniently obtained.

COST OF WASHING PER TON.—ON BASIS OF DAILY OUTPUT OF 300 TONS.

			Cost per Ton.
Labor Washing.			
1 Foreman @ $3.00		$ 3.00	
3 Jigmen	1.50	4.50	
2 Feeders	1.00	2.00	
1 Oiler	75	.75	
1 Engineer and Fireman @ $2.00		2.00	
		$12.25÷300	.04
Slate Picking.			
6 slate pickers @ $1.00		$ 6.00÷300	.02
Fuel, water, daily		4.00÷300	.013
Oil, supplies, etc.		2.00÷300	.006
Maintenance and repairs, etc., to jigs, jig sieves, screens		1200 yearly.	.01
Emergencies. Renewals and repairs to other machinery.		900 "	.015
Total cost of washing per ton			.10.4

IMPROVEMENT OF COAL EFFECTED BY WASHING.

The extent to which coal can be improved by washing, will depend upon the nature of the coal, the shape of its particles, the relative specific gravity of the coal, and its impurities, and whether there are also present impurities of intermediate specific gravity as bony and slatey coal.

In treating a southwestern coal of the Laramie group of the Upper Cretaceous Formation in a plant similar to the above, the results obtained were as follows:

The plant here shown contains some important additions for handling of the large coal, intermediate products and treatment and settling of the fines, as well as other improvements.

The treatment in sizing and washing, however, are similar.

Some of the very purest coal which was in small quantity and friable, analyzed as shown in No. (1), its ash representing combined or fixed ash which could not be removed by any process.

No. 2 represents an analysis of selected lumps with no visible impurities adhering to them.

	No. 1.	No. 2.
Moisture		0.39
Volatile Combustible Matter	20.35	19.75
Fixed Carbon	79.30	64.36
Ash	8.35	14.65
Sulphur		0.85

The analysis of the ash is as follows:

Silica	7.30
Iron	1.01
Lime	.83
Alumina	5.10

The Specific Gravity of the lightest weight coal was 1.39; of bony and slatey coal 1.5 to 1.9; of slate and other impurities 1.8 to 2.3.

There were also associated thin flakes of spar, lime and slates.

The material used for washing was screenings passing through a 1½" bar screen, whose analysis, as well as that of the resulting products are shown below, when the washer was not overcrowded.

	Raw Screenings.	Washed Coal.	Coke.	Refuse from Waste Box.
Moisture	1.40	.79	0.43	2.22
Volatile Combustible Matter	19.79	19.10	1.39	15.76
Fixed Carbon	60.25	69.35	83.47	30.96
Ash	17.33	10.24	14.24	50.12
Sulphur	.85	.52	.82	.93
Phosphorus			.019	

The ash in the screenings was reduced in washing from 17.33% to 10.24%.

The inherent ash in the purest coal being 8.35% and somewhat higher in the average coal. The washing, therefore, reduced the ash to within 1.89 , or less of the combined ash.

The yield of washed coal from raw coal was 85%, or 15% of the material was removed as impurities from the raw coal, which consisted of slate, and some of the poorer quality of coal as bony and slatey coal. The washed coal was used for coke. The yield of coke from washed coal was 70%, or the yield of coke from raw coal was 59½%, and contained 14.24% of ashwith close washing. In other words, 4½ gross tons of raw coal, when washed, yielded 3.82 tons of coal, which was charged in a Beehive coke oven 6½ feet high and 12 feet diameter, and burned 48 hours, yielding 2.67 tons of coke.

Prior to washing the raw screening yielded 66 to 70% of coke, much being lost as coke ashes and containing 20 to 22% of ash.

LECTURE NOTES ON ROCKS.*

For Use Without the Microscope.

By J. F. KEMP.

Chapter IX. The Metamorphic Rocks. Introduction. The Rocks Produced by Contact Metamorphism.

The word metamorphism was first introduced into geological literature by Lyell in 1832, and was used to describe the processes by which rocks undergo alteration. It was particularly applied by him to those stratified rocks that, from deep burial in the earth, and from the consequent heat and pressure to which they have been subjected, have assumed structures and textures resembling those of the unstratified primary or plutonic. In this sense it has been generally employed since, and it implies an increase in crystallization, hardness and those attributes which are especially associated with the crystalline schists, as contrasted with the unaltered sediments.

The literal meaning of the phrase "the processes by which rocks undergo alteration" may nevertheless, be somewhat more comprehensive than this, and may be made to include the changes produced by atmospheric agents, which we ordinarily describe by the term weathering, and in the following pages the products of this latter form of alteration will be briefly considered as a third and concluding group.

The metamorphic works will therefore be taken up under the following three classes.

I. Rocks reduced by Contact Metamorphism.
II. Rocks produced by Regional Metamorphism.
III. Rocks produced by Atmospheric Weathering.

By contact metamorphism is meant the series of changes that are effected by an igneous intrusion, such as a dike or a laccolite upon the rocks through which it is intruded. These changes are often profound, and are brought about by the heat of the intrusion

* Copyrighted by the author. Continued from p. 295 of the April Quarterly.

Errata, not previously noted. P. 156, 6th line from bottom, presence, not presenec; p. 138, 6th line, dunite, not dunnite; 26th line, types, not type; p. 278, the reference to analysis I, is wrong. The analysis is of a damourite slate. A mistake in copying was made. See Chapter XI; p. 290, 3d line, IV, not III.

as well as by vapors and hot solutions which it may likewise give forth. The wall-rock may be itself igneous or sedimentary, or even metamorphic. This form of metamorphism is sometimes called "local" as contrasted with "regional."

By regional metamorphism we describe the series of changes that are produced in the rocks of wide areas or "regions" by deep burial, mountain-making upheavals, and by heat and pressure. Although Lyell had stratified rocks before him as the chief materials on which these agents acted, yet it is well recognized to-day that igneous rocks are no less profoundly affected, and indeed that the results of their alteration may be almost or quite indistinguishable, from those derived from sediments. But there is great uncertainty as to the original condition of many regionally metamorphosed rocks, and although the endeavor has been made in previous pages to throw as much light upon them as possible, by systematically referring to the alteration and metamorphism of simple types, nevertheless, many are obscure, and in their history are involved some of the profoundest problems of geology.

By atmospheric weathering is meant the series of changes wrought in rocks at or near the surface of the earth, by the ordinary atmospheric agents, water, oxygen, carbonic acid and the like. The changes are chiefly in the nature of disintegration, loss of soluble ingredients and decomposition, and in general they produce a marked shrinkage of bulk.

It is important to appreciate that under whatever form the metamorphic rocks are met, they are of necessity alteration products of the two grand divisions over which we have already passed.

Generalities Regarding Contact Metamorphism.

Widening observation has shown that contact metamorphism is produced by all varieties of igneous rocks, and that it may be broadly stated to be independent of the kind of rock forming the intrusion. Granites, syenites, nepheline-syenites, diorites, gabbros and even peridotites have in one place and another proved to be efficient agents. Yet the following statements may be said to hold good:

1. Plutonic rocks are more favorable to it than volcanic. This follows because plutonic rocks cool slowly, at considerable depths and stand therefore at high temperatures for long periods next their walls.

2. Magmas rich in mineralizers are much more favorable than are those poor in them. This naturally follows from the powerful influence exerted by escaping vapors. It is tantamount to saying that acidic rocks are in general more efficient than basic ones, because experiment shows, and field observation indicates, that abundant absorbed vapors accompany and facilitate the fusion of the rocks high in silica, whereas basic rocks are much more largely the results of dry fusion. Granites, for instance, are the commonest and most effective agents of contact metamorphism.

3. As regards the walls, sedimentary rocks possess varying susceptibilities. Highly siliceous sandstones and conglomerates, for example, are stubborn subjects, and manifest but slight alteration; but highly aluminous or calcareous beds are favorable to recrystallization because they contain the alumina, iron, lime, magnesia and the alkalies that will combine with silica, under metamorphosing influences, to yield copious contact minerals. Of all rocks, impure limestones yield the most varied and interesting results.

4. With a favorable intrusion, the apparent distance to which the metamorphosing influence penetrates, depends on the angle of emergence of the intrusion. If it comes up at a low angle it may lie but a short distance below the surface for a considerable stretch on one side of the outcrop, so that the metamorphosed area may apparently extend to a great distance, although at no point far from the source of heat. Around a vertical dike the distance would naturally be less. Again, the alterations progress much less readily across the bedding of stratified rocks than along it. Hence, an intrusion that cuts across the bedding produces more widespread effects than does one parallel with it.

5. It is believed by many, especially among English and German observers, that there is very slight migration of material during metamorphism, and therefore that the contact minerals have resulted from the silica, and the bases that were practically in the same places before the intrusion as after it. It follows that there has been no chemical introduction or substitution, but only rearrangement of molecules during the process. An analysis, therefore, of a reasonably large-sized sample would indicate the composition of the original rock, except so far as water, carbonic acid, and other volatile ingredients have been driven off. From observations upon an intrusion of granite in Westmoreland, England, that cuts a decomposed, basic, amygdaloidal lava, Alfred Harker

concluded that the migration had not exceeded one-twentieth of an inch. But among the French much greater power of chemically affecting the walls is attributed to intrusions, and in instances it certainly seems as if, in addition to the fluorine and boron that we all know penetrate into wall rocks during the escape of mineralizers, hydro-fluosilicic acid might impart silica and that some of the bases, and especially the alkalies, might migrate in heated solutions, to a moderate distance.

6. Notwithstanding the truth of the foregoing generalities, it is a curious fact that contact effects are sometimes strangely lacking where we would naturally expect them, and that they are often of varying intensity and irregular distribution, where they do occur. These anomalies can in part be explained by the general principles already cited, of which no doubt the presence or absence of mineralizers, the superheated or relatively cold condition of the intrusion are chief. But every observer of wide experience is sometimes much puzzled by what he meets in nature.

I. The Rocks Produced by Contact Metamorphism.

Although the principal results of contact metamorphism are manifested in the walls of the intrusion, the igneous rock is itself influenced. It is therefore necessary to note both the *internal* and the *external* effects, or those upon the intrusion and those upon the walls. The area over which the latter are manifested is often called the aureole, and the concentric rings of decreasing alteration as one passes outward from the intrusion are called zones.

Internal Effects. The igneous rock suffers a relatively rapid loss of heat in its marginal portions as compared with its interior, and as a result it very commonly assumes a porphyritic, felsitic or even, just at the contact, a glassy texture, although it may be granitoid within. Where these textures are well developed the passage from one to the other is extremely gradual, and if the wall rock has been originally a shale or a clay that has been baked to a dense mass, it may need microscopic examination to determine where the intrusion ends and the wall rock begins. The changes in texture in the intrusion are accompanied more or less by changes in chemical composition and in not a few cases progressive analyses have shown the margins to be much more basic than the interior of the intrusion. The chilling of the former has thus

produced chemical rearrangements in the magma previous to consolidation.

External Effects. Recalling the statement earlier made that within the limits already set forth the character of the intrusion is immaterial, the most convenient and intelligible method of treatment will be to briefly outline several typical cases wherein the commoner sedimentary rocks are known to have been affected, and then to refer, to one or two instances wherein igneous or regionally metamorphic ones have suffered alteration. The same order will be preserved for the sediments as appears under Chapters VII and VIII.

Breccias are too limited in distribution to be a serious factor. Conglomerates and sandstones so generally consist of silica, that they supply but little raw materials of a favorable kind. The small amounts of alumina present may combine with the silica to afford sillimanite (Al_2O_3 ,SiO_2) and stimulated circulations of hot water may cause added deposition of quartz around the grains so as to develop increased hardness.

With shales and clay rocks, even if in the form of slate (see later p. 423) the effects are more pronounced; and around intrusions in them well-marked and well identified zones have been described.

At the contact of the igneous rock with the sediments a breccia or "mixed zone" of intrusive and fragments of wall rock is sometimes, although not always, met. More commonly the shales, slates, clay or their kindred rocks are baked and altered to a dense, flinty product known as a hornfels or hornstone, which latter name in this sense, is however, not to be confused with its use for flints and cherts. It breaks in irregular, angular masses and has a very close resemblance to dense trap. Its mineralogy is, as a general thing, a subject for microscopic study, but it may be said that biotite in small scales is rather the most widespread mineral present, and that andalusite, garnet, cyanite, staurolite, tourmaline, ottrelite, rutile, hornblende, feldspars and other minerals more or less characteristic of such surroundings frequently appear. They may be of considerable size and the prisms of andalusite of the variety chiastolite with the light and dark maltese crosses showing in their cross-sections, are especially frequent. As the contact is left the hornfels often passes into mica schist. Farther out the mineralogical changes become less marked; the andalusite and other crystals are less and less well developed and

finally shade into mere dark spots or aggregates of biotite, magnetite and bituminous matter. When even these fade out the unchanged sediment is met. In some localities it has therefore been possible to establish three zones, which are in the reverse order of the above succession, the knotty or spotted slates, the knotty mica schists, and the hornfels, usually with andalusite. By knotty is meant the aspect given by the larger contact minerals in the midst of finer aggregates.

These are the names adopted for a well known contact studied by the eminent German petrographer, Rosenbusch, in the Vosges Mountains. At a famous American locality in the Crawford Notch of the White Mountains, on the slopes of Mt. Willard and not far from the Crawford House, the granite has penetrated an argillitic mica schist or micaceous slate, and the zones are somewhat different. G. W. Hawes in 1881 established the following seven: 1. The argillitic mica schist (chloritic); 2. Mica schist (biotitic); 3. Tourmaline hornstone; 4. Tourmaline veinstone (a small contact band, rich in tourmaline); 5. Mixed schists and granite; 6. Granite porphyry (biotitic); 7. Granite (hornblendic). This is one of the most complete and well-exposed contacts known, and illustrates both external and internal effects.* The succession illustrates the alteration of chlorite to biotite by the granite, and then near the contact the development of tourmaline from the boracic and fluoric emanations which were afforded by it. On the southeast corner of Conanicut Island, in Narragansett Bay, granite has penetrated Carboniferous shales, as described by L. V. Pirsson,† and has baked them to compact hornfels near the contact. Spotted slates are likewise met resembling those described above. Immediately beneath the diabase of the Palisade ridge at Hoboken, N. J., the Triassic shales are baked to a compact hornstone with abundant tourmalines, and near Beemerville, N. J.,‡ a great dike of nepheline-syenite has come up through Ordovician shales and has baked them in places to remarkably dense black hornstones. Near Crugers, on the Hudson River, mica-diorites have penetrated mica schists and have developed in them a considerable number of characteristic contact minerals, but the

* Hawes' paper is in the American Journal of Science, January, 1881, p. 21.

† L. V. Pirsson, On the Geology and Petrography of Conanicut Island, R. I. *Amer. Jour. of Sci.*, Nov., 1893, p. 363.

‡ J. F. Kemp. *Trans. New York Acad. Sci.*, xi. p. 60.

changes in the schists are not specially apparent to the eye.* As western and other eastern areas are further studied, no doubt additional cases will be fully described. Many are known and await careful field work.

The contact effects on limestones furnish extremely interesting phenomena and a series of minerals somewhat different from those just described. On account of the general lack of migration of material the elements of the minerals must be present in the unaltered rock. Pure limestone therefore merely crystallize into equally pure marbles. Siliceous and argillaceous ones are thickly charged with biotite, garnet, vesuvianite, scapolite, pyroxenes and amphiboles, tourmaline, spinel, and not a few more. Garnet and vesuvianite are especially characteristic. Good contacts have been met at several American localities. Near St. John, N. B.,† granite has penetrated Laurentian limestone and has developed a garnet zone, with more or less pyroxene. Diorites cutting or including limestone in the Cortland series‡ have caused the formation of pyroxene, scapolite, hornblende and other minerals.

In the valley extending from Warwick, N. Y., southwest to Sparta, N. J., are most instructive exhibitions, and rich mineral localities are based on them. Granite is the principal intrusive.§ The western Adirondack region of New York contains many more where gabbro and limestone come together, and where the well known mineral localities occur. C. H. Smyth, Jr., has lately identified their contact nature and will in time describe them. Abroad, the region about Christiania in Norway has proved to be classic ground for these phenomena, and a great contact of diorite on Triassic limestone at Predazzo in the Tyrolese Alps has produced the characteristic zones on a grand scale.

The inclusions of wall rock caught up by an advancing intrusion on its way to the surface are instructive examples, and often are afterwards found entombed in the igneous rock and more or less altered. The lava flows of Vesuvius and the ejected bombs have been of extraordinary interest in this respect. Limestones are frequent among them and they exhibit the same zones as the larger occurrences. Vesuvianite, in fact, received its name from this association.

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* G. H. Williams. *Amer. Jour. Sci.*, Oct., 1888, p. 265.

†W. D. Matthew, *Trans. N. Y. Acad. Sci.* XIII., 194.

‡G. H. Williams, *Amer. Jour. Sci.*, Oct., 1888, 267.

§J. F. Kemp and Arthur Hollick *Annals N. Y. Acad. Sci.* VII., 644.

Of the remaining members of the grand division of the Aqueous rocks, the Carbonaceous are the principal ones deserving mention. Coal seams of the normal bituminous variety have been cut in not a few places by igneous dikes, and display in a marked degree the metamorphosing effect. The volatile hydrocarbons are driven off and the coal becomes an impure coke. The Triassic coal basins of Virginia and North Carolina exhibit many instances where diabase dikes have wrought the change, and in the region of Puget Sound basalt intrusions have effected similar results. In Colorado and New Mexico, the near approach of an igneous sheet has brought about the formation of anthracite, and in fact all grades of coal can be detected from rich bituminous to hard anthracite, according to the nearness of the dike or laccolite.

Reference may also be made to the hills of soft magnetite, near Cornwall, Penn., where a great dike of diabase has altered imonite to this more crystalline and thoroughly anhydrous mineral.

Where intrusions cut other igneous or metamorphic rocks the effects are much less apparent, because the walls are resistant to change, being themselves already crystalline. Around granites, however, even in these conditions, great pegmatite dikes and veins are copiously produced, which seems to be in large part brought about by escaping heated vapors and solutions.

Remarkable cases of contact metamorphism are, however, certainly caused by these last named agents. As rocks they are not specially abundant, although of great scientific interest. Some intrusions have emitted copious emanations of hydrofluoric and boracic acid in conjunction with superheated steam. These vigorous reagents have attacked the wall rocks, when originally formed of crystalline silicates, making them porous and cellular from the destruction of feldspars, and have often caused the crystallization of quartz, tourmaline, topaz, fluoric micas, fluorite, apatite and other characteristic minerals of which cassiterite is of much economic importance. Such metamorphic products when essentially consisting of quartz and mica are called greisen. Tourmaline granites likewise result. It is not to be overlooked, however, that mineralizers have also played a large part in the cases earlier cited, nor should the remark be omitted in conclusion that they and similar agents have been of vast practical importance in the formation of ores.

CHAPTER X. THE METAMORPHIC ROCKS, CONTINUED. THE ROCKS PRODUCED BY REGIONAL METAMORPHISM. INTRODUCTION. THE GNEISSES AND CRYSTALLINE SCHISTS.

INTRODUCTION.

This subdivision embraces rocks that differ widely among themselves, but that have nevertheless important features in common. The following generalities are applicable in a large way and will serve to emphasize some of the most important points.

1. Regionally metamorphosed rocks are all more or less perfectly crystalline. This is least developed in the slates.

2. They are all more or less decidedly laminated or foliated, although some amphibolites, marbles and serpentines are quite massive. The laminations are due to the arrangement of the constituent minerals, and especially the dark-colored ones, in parallel alignment, so that light and dark layers stand out conspicuously. The terms bedded and stratified should never be applied to them because the banding is largely due to dynamical processes, and has no necessary connection with original sedimentation.

3. They are of ancient geological age or else are in greatly disturbed districts.

It is important in connection with these rocks to distinguish between the effects produced by heat or thermal metamorphism and the effects produced by mechanical forces or dynamic metamorphism. By thermal metamorphism we understand the alterations caused by heat not necessarily accompanied by the mechanical effects such as shearing, crushing and the like, that are comprehended under dynamic metamorphism. Contact metamorphism is of course a variety of the former which, however, is also brought into play alike when rocks are so deeply buried that they come within the sphere of influence of the earth's interior heat, and when from dynamic stresses, they are crushed so that their particles move or slide under great pressure on one another and develop heat by friction. If we imagine for a moment great bodies of rocks which have definite crushing resistances, buried under a load of overlying strata so deep within the earth that their limits of resistance are exceeded, yet so confined that they cannot fly apart, we perceive that they must yield by internal crushing, and if the upheaval of a mountain range eases the strain, that they must flow in a mass. It is to this flow, accompanied by shearing, that the

lamination of metamorphic rocks is largely due. Prominent or conspicuous minerals are strung out in parallel alignment, oftentimes with wavy folds and curves, and in the end a foliated or laminated structure is superinduced that suggested the bedding of sediments to the early geologists. It is not to be denied, however, that the laminations do at times correspond to original bedding, because where the contrasts in chemical and mineralogical composition, among the layers are pronounced, they doubtless mark such correspondence, but cases are well known of old conglomerate beds passing directly across the prevailing schistosity of a gneissic district.

During these shearing and flow movements larger crystals, such as the feldspar of porphyries, or the uncrushed nuclei of minerals in a general pulp are squeezed and stretched into lenses, and remain like eyes between eyebrows, so that they are called "Augen" from the German word for eyes. Swirling curves and eddies in the laminations are also familiar phenomena and cannot be explained in any other way.

These changes may take place without mineralogical alteration, as when granitoid rocks pass into gneisses that contain simply the crushed fragments of the originals, but as a general thing new combinations are formed in the metamorphosed rock. Pyroxene passes into hornblende; soda-lime feldspars become scapolite or saussurite, and other changes ensue that are best detected with the microscope. Sedimentary rocks suffer entire recrystallization, and sometimes so thoroughly lose their original characters that no clue is afforded as to their history. In regional metamorphism precisely as in the case of the contact metamorphic rocks, it is generally believed that there is no change in composition, except perhaps by the loss of volatilizable ingredients, but only rearrangement of elements. A gross analysis of a reasonably large sample will therefore give a clue to the composition of the original. Heated waters, generally charged with mineral matter and steam have no doubt contributed largely in bringing about the final result.

The Regionally Metamorphosed rocks will be described under the following heads:

1. The Gneisses and Crystalline Schists.
2. The Quartzites and Slates.
3. The Crystalline Limestones and Dolomites: The Ophicalcites, Serpentines and Soapstones.

The Gneisses.

Introductory.—Gneiss is an old word, that originated among the early German miners in the Saxon districts. It was especially applied by them to laminated rocks of the mineralogical composition of granite, and in this sense it is quite widely employed to-day. But there are many important gneisses that correspond in mineralogy to the other plutonic rocks, and that are quite as properly designated by this name, so that gneiss has come to be a term that is of loose geological significance very much as is trap, but that is none the less useful for this reason. We may therefore define gneiss as a laminated, metamorphic rock that usually corresponds in mineralogy to some one of the plutonic types. Gneisses differ from schists in the coarseness of the laminations, but as these become finer they pass into schists by insensible gradations. Varieties are sometimes indicated by prefixing the name of the most prominent silicate, usually one of the ferro-magnesian group, thus hornblende-gneiss, biotite-gneiss, pyroxene-gneiss, but we also often speak of quartz-gneiss, orthoclase-gneiss, plagioclase-gneiss, garnet-gneiss and the like.

It is evident at once that the above names are incomplete. Hornblende-gneiss, for instance, does not indicate whether the rock contains orthoclase or plagioclase, quartz or no quartz, and the other ones cited are open to the same or similar objections, and if in the endeavor to embody fuller descriptions we string together the names of all the minerals in the rock, we employ an objectionable and awkward method of coining names. A system has, however, been suggested by C. H. Gordon,* in a recent paper that obviates many of these objections and that is adopted below with some abbreviations suitable for an elementary book. It is based on the parallelism that exists between the mineralogy of gneisses and that of the massive plutonic rocks, and it avails itself of the short names of the latter, that indicate in each case, a definite combination of minerals to describe the aggregates present in the former. Two sedimentary terms are also added.

*Bulletin of the Geological Society of America, VII., 122.

Massive Type.	Gneiss of Correspond-ing Mineralogy.	Sedimentary Type.	Derived Gneiss.
Granite	Granitic Gneiss	Conglomerate	Conglomerate Gneiss
Syenite	Syenitic Gneiss	Sandstone	Quartzite Gneiss
Diorite	Dioritic Gneiss		
Gabbro	Gabbroic Gneiss		
Pyroxenite	Pyroxenitic Gneiss		
Peridotite	Peridotitic Gneiss		

Dr. Gordon also suggests that when gneisses are evidently dynamic derivatives from a massive rock, that this relationship be indicated by using the terms granite-gneiss, syenite-gneiss and so on. If, however, differentiations in the magma before crystallizing have given rise to laminations, that such be distinguished by the adjective gneissoid, as gneissoid gabbros.

Gneisses are occasionally met which do not exactly correspond to any of the above names. Chlorite, for example, is a not uncommon mineral, and while it is evidently an alteration product from pyroxene, hornblende or biotite, the original mineral is not at once apparent, and some such name as chlorite-gneiss must be used. In the same way cordierite-gneiss describes those rare varieties containing cordierite (iolite and dichroite are synonyms of cordierite); sillimanite-gneiss, garnet-gneiss, epidote-gneiss and others convey in their names their characteristic features.

Analyses of Gneisses.

Chemical analyses often enable us to trace back gneisses to their original rocks, whether igneous or sedimentary, but it requires careful study of correct type analyses and some familiarity with their ranges in composition to do it. So far as their number admits the analyses quoted on earlier pages will be found suggestive:

	SiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	CaO.	MgO.	K_2O.	Na_2O.	Loss or H_2O.
1.	76.61	12.45	. .	1.33	0.84	. .	5.42	3.12	0.53
2.	74.95	9.42	7.47	. .	1.65	0.13	2.02	4.05	1.02
3.	73.47	15.07	1.15		4.48	0.12	0 38	5.59	. .
4.	71.46	15.06	. .	2.43	1.40	0.42	5.17	3.23	0.83
5.	69.35	18.83	2.00		5.94	. .	3.78		. .
6.	69 94	14.85	7.62	. .	2.10	0.97	4.33	4.30	0.70
7.	61.96	19.73	. .	4.60	0.35	1.81	2.50	0.79	1.82
8.	57.66	22.83	. .	7.74	1.16	3.56	5.72	0.60	1.50
9.	57.20	19.57	9.52	0.59	5.73	4.40	0.28	2.13	0.88
10.	54.89	13.67	1.35	. .	5.63	4.70	8.34	1.95	2.76

1. Granitic gneiss, west side of Black Hills *40th Par. Survey*, I. p. 110. R. W. Woodward, Anal. 2. Called a dioritic gneiss in reference, contains hornblende, quartz, plagioclase, orthoclase. *Idem.*: R. W. Bunsen, Anal. 3. Conglomerate gneiss, so-called granite; Munson, Mass. Quoted by G. P. Merrill, *Stones for Building and Decoration* p. 418. 4. Granitic gneiss, Iron Mountain, Wyo. R. W. Woodward, Anal. See under No. 1. 5. Dark variety of No. 3. 6. Granite gneiss, derived from a hornblende granite, Trembling Mountain, Quebec, Fundamental Laurentian of Logan. F. D. Adams, *Amer. Jour. Sci.*, July, 1895, p. 67. W. C. Adams, Anal. 7. Quartzitic gneiss, with garnet, sillimanite, graphite and pyrite; St. Jean de Matha, Quebec. *Idem.* N. N. Evans, Anal. 8. Granitic gneiss, probably a metamorphosed clay or slate. Trembling Lake, Quebec. Contains garnets and sillimanite. F. D. Adams, *Amer. Jour. Sci.*, July, 1895, p. 67. W. C. Adams, Anal. 9. Dioritic gneiss, New York City. P. Schweitzer. *Amer. Chemist*, VI. 457, 1876. 10. Gneiss containing malacolite, scapolite, orthoclase, graphite, pyrite. Rawdon, Quebec. See under No. 8.

Comments on the Analyses. Nos. 1, 4 and 6 are clearly derived from granites, presumably by dynamic metamorphism. The analyses correspond closely in their general features with those given on p. 138 except that the Al_2O_3 of No. 1 is a trifle low, and the Fe_2O_3 of No. 6 a trifle high. Nos. 3 and 5 are now known to be metamorphosed Cambrian conglomerate, although so thoroughly recrystallized as to be a well known commercial granite. The conglomerate must have come from granitic or dioritic original rocks. Nos. 7 and 8 correspond to the analyses of slates as noted by F. D. Adams in the original reference (see also under slates, p. 423). No. 10 as noted by Adams is of doubtful interpretation. The high alkalies, lime, magnesia and the moderate silica suggest a basic syenite or trachyte, but the alumina is exceptionally low for these. It may be a tuff or a slightly altered sediment from these originals. No. 2 is a very anomalous rock, and it is difficult to refer it to an original diorite, it is so high in silica and so low in alumina. The iron is very large for so acidic a rock. No. 9 is undoubtedly an altered sediment as indicated by the local geology. Notwithstanding the anomalies of composition, chemical analyses supply one of the surest clues to the geological history of gneisses and it is to be hoped that they will be multiplied in America. At present but few are available, far fewer than of igneous rocks.

Alteration. The alteration of gneisses is similar in all respects to that of their corresponding massive types. The feldspars alter to kaolin, the micas and hornblende to chlorite and the rock softens down to loose aggregates that contribute heavily to the sedimentary rocks.

Distribution. Gneisses are abundant in ancient, geological formations. The early Archean is their especial home, and they form the largest part of its vast areas in Canada, around the Great Lakes, along the Appalachians and in the Cordilleran region. But no single geological age monopolizes them any more than plutonic rocks. There are Cambrian and even Carboniferous gneisses in New England, and dynamic metamorphism may produce them from massive rocks of almost any age. The later geological formations are, however, seldom buried sufficiently deep to be in favorable situations. Much the same holds true of Europe and the rest of the world. The gray and red gneisses of the mining districts about Freiberg, in Saxony, those of the Highlands of Scotland, and in Scandinavia, and the wonderful exhibitions of dynamic metamorphism in the Alps are to be cited as of unusual historic and scientific interest.

Granulite. Granulite is a word that has possessed somewhat contrasted meanings according as it has been used in Germany, France or England. In Germany as first employed it was applied to a finely gneissoid rock that consists chiefly of feldspar, quartz and garnets. These original granulites have other minerals more or less prominently developed, of which cyanite, augite, biotite and hornblende are chief. The texture of the rock is extremely dense, and except for the garnets, cyanite or augite the individual minerals are hardly discernible. Among French and English speaking peoples granulite has been applied to granitic rocks that appear to the eye to be chiefly quartz and feldspar, although the microscope may show muscovite. They are practically binary granites, or rich quartz and feldspar gneisses. The name has also been used for coarse plutonic rocks that have been crushed down by dynamic metamorphism into a finely granular and homogeneous aggregate. But so far as metamorphic rocks have been met in America, cases are very rare which cannot be satisfactory described without the use of this word, that has been so perverted from its original application as to be practically valueless without an accompanying explanation.

The Crystalline Schists.

The crystalline schists have finer laminations than the gneisses, but in other respects the mineralogy is often much the same, and as already stated no very sharp line can be drawn between them.

It is important to note that the words "schiste" of the French and "Schiefer" of the Germans are applied to shales, slates and metamorphic schists indiscriminately, but in English schist is only used for metamorphic rocks. The more important schists are broadly classified according to the principal ferro-magnesian silicate that is present into the following three groups under which they will be taken up.

(a) Mica-schists.
(b) Hornblende-schists or Amphibolites.
(c) Various Minor Schists.

THE MICA SCHISTS.

	SiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	CaO.	MgO.	K_2O.	Na_2O.	H_2O.
1.	82.38	11.84	. .	2.28	. .	1.00	0.83	0.38	0.77
2.	79.50	13.36	2.87	. .	0.71	0.95	4.69	0.36	0.78
3.	69.45	14.24	. .	6.54	2.66	1.35	2.52	4.02	0.52
4.	66.21	18.60	. .	5.34	0.44	1.24	3.80	2.16	2.04
5.	62.98	16.88	2.48	5.00	tr.	1.58	7.45	3.02	. .
6.	61.57	19.53	5.44	2.61	tr.	1.90	2.14	3.48	. .
7.	60.49	19.35	0.48	5.98	1.08	2.89	3.44	2.55	3.66
8.	57.67	17.92	. .	9.00	3.19	3 29	3.86	1.09	3.19
9.	55.12	24.32	6.13	4.99	tr.	tr.	2.83	2.71	. .
10.	49.00	23.65	8.07	. .	0.63	0.94	9.11	1.75	3.41

1. Mica-schist, rich in quartz, Monte Rosa, Switzerland., Zulkowsky, *Sits. Wiener Akad.* XXXIV., 41, 1895. 2. Mica-schist, with quartz and green mica Zermatt. Switzerland. Bunsen in *Roth's Tabellen*, 1862. 3. Garnetiferous mica schist with feldspar, Brixen. Tyrol. Schönfeld and Roscoe, *Ann. der. Chem. u. Phar.*, XCI., 1854. 305. 4. Mica-schist near Meissen, Saxony, Hilger quoted in *Roth's Tabellen*, 1879. 5. Mica-schist, Crugers, N. Y., contains quartz, orthoclase, biotite, muscovite, little oligoclase, etc. F. L. Nason for G. H. Williams, *Amer. Jour. Sci.*, Oct., 1888. 259. 6. Crumpled garnetiferous mica-schists. *Idem.* 7. Argillitic mica-schist, G. W. Hawes, *Geology of New Hampshire, Part III.* 219. 8. Mica-schist near Messina, Sicily, Ricciardi. Quoted in *Roth's Tabellen*, 1884, p. ix. 9. Staurolite mica-schist, with biotite, muscovite, quartz, sillimanite, garnet. See under No. 6. 10. Sericite schist, Wisconsin, *Wis. Geol. Surv.*, I. 304.

Comments on the Analyses. Like the majority of gneisses the mica-schists are more or less closely parallel with the granites in chemical composition because the constituent minerals are so largely the same in both. But where they have been formed from metamorphosed sediments such as shales, clays, and the like, the alkalies are often lower than is the case with siliceous igneous rocks, and, what is still more characteristic of sediments as contrasted with highly siliceous igneous rocks, the magnesia is

in excess of the lime. A comparison of the above analyses with those of the rhyolites, trachytes, granites and syenites earlier given will forcibly bring this out. The local geology as well as the analyses, indicate that there is little doubt that Nos. 5, 6, 7 and 9 are altered sediments, and the presumption is strong that most of the others are also.

Mineralogical Composition. Varieties. The most prominent and abundant minerals in the mica-schists are quartz, muscovite and biotite. While they are more or less interleaved together, yet close examination of the coarser varieties shows that they are in layers irregularly parallel and to a large extent distinct. The minerals are in all degrees of relative abundance, quartz sometimes largely predominating and marking a passage to the quartzites, while again the micas may be in great excess. Both muscovite and biotite are met, the former being, perhaps, rather the more abundant. With these chief minerals are almost always associated very considerable amounts of feldspar, both orthoclase and plagioclase, and variable proportions of garnet, staurolite, cyanite, sillimanite, tourmaline, apatite, pyrite and magnetite.

The garnet and staurolite may exhibit surprisingly well developed crystals and illustrate the extraordinary power of certain compounds to crystallize under circumstances apparently ill-adapted to their perfect development.

Mica-schists embrace a series from rather coarsely crystalline varieties to others that are excessively fine-grained and that are near relatives of the slates. The minerals of the latter may be of microscopic dimensions, and only the aggregate of shining scales reveals them as mica. Such aggregates, of a silvery white color but of composition essentially the same as normal muscovite, are called sericite, and the corresponding schists, sericite-schists. A related soda-mica (muscovite and its relatives are potash micas) is called paragonite. Hydromica is a name applied many years ago by Dana to sericite, paragonite, and perhaps others resembling them, so that for these finely micaceous schists, especially in our eastern states, hydromica schist is a field name that is largely used in practice and in geological reports. These fine-grained mica-schists that approximate slates are also made a special group by many, under the name phyllite, a very useful term and one to be strongly commended. Mica-schists are also met that are high in lime and that mark transitions to the crystalline limestones.

The abundance of calcite or dolomite betrays them, and to such the names calcareous schist or calc-schist are applied.

Mica-schists result from the thorough metamorphism or recrystallization of sandstones, shales and clays, and also from the crushing and excessive shearing of igneous rocks, granitoid and porphyritic alike. A possible origin from ancient volcanic tuffs is always to be considered in the study of a district, but the questions of origin are obscure and are subjects for thorough chemical and microscopical investigation.

Alteration. The mica-schists are rather resistant to alteration and often appear on mountain tops. When alteration does prevail, they soften to masses of quartz sand, chlorite scales and kaolin.

Distribution. The mica-schists form the country rock over vast areas in New England and to the south along the eastern Appalachians. Although long regarded as of uncertain or obscure geological relations they are now recognized in large part at least as metamorphosed Cambrian and Ordovician shales or related sediments. Around Lake Superior and in the regionally metamorphosed areas of the West they are not lacking.

The Hornblende Schists or Amphibolites.

Introductory.—Under dynamic metamorphism the basic igneous rocks whose chief bisilicate is pyroxene, pass very readily into hornblendic rocks, with a greater or less development of schistosity. On account of the prevailing parallel arrangement of the prismatic crystals of hornblende, schistosity is seldom entirely lacking, but where less distinct the name amphibolite has proved to be a useful alternative, and indeed is of wide general application. Sedimentary rocks are also known in rarer instances to yield similar results.

	SiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	CaO.	MgO.	K_2O.	Na_2O.	H_2O.
1.	52.39	16.13	1.64	1.44	8.76	4.70	1.42	2.59	0.17
2.	50.44	8.18	1.06	6.28	11.55	17.63	0.50	2.98	0.98
3.	49.19	18.71	5.03	4.04	5.92	7.98	0.77	1.44	5.05
4.	46.31	11.14		21.69	9.68	tr.		6.91	4.44
5.	44.49	16.37	5 07	5.50	7.94	7.50	0.56	2.59	4.99

1. Hornblende-schist, Grand Rapids, Wis. *Geology of Wis.* IV. 629. Also, Fe in pyrite, 0.34; S, 0.39; P_2O_5, 0.28 Ca in apatite 0.815. 2. Pseudo-diorite of Becker, Knoxville, Calif. *Monograph XIII. U. S. Geol. Surv. 101*, W. H. Melville, Anal. Also, MnO 0.213, Cr_2O_3 0.480. 3. Hornblende-schist derived from gabbro, Lower Quinnesec Basin, Wis. R. B. Riggs for G. H. Williams, *Bull. 62 U. S. Geol. Surv.*

p. 89. Also CO_2 1.82. 4. Hornblende-schist near Cleveland Mine, Mich. Foster and Whitney *Rept. on the Iron Lands of Lake Superior.* p. 92. 5. Hornblende-schist, Lower Quinnesec Falls, Wis. R. B. Riggs for G. H. Williams, *Bull. 62. U. S. Geol. Surv.* p. 91. Also CO_2 5.38.

Comments on the Analyses. The analyses indicate basic rocks, of decidedly variable composition. Nos. 3 and 5 are certainly sheared igneous rocks. No. 2 is regarded by Becker as a metamorphosed sediment. It is quite different from the others in its low alumina, and its great excess of magnesia over lime. No. 1 appears to be an altered igneous rock and No. 4 is probably the same. Aside from exhibiting the composition of these rocks, the analyses are interesting when compared with those of the basic diorites (p.153) and the gabbros and pyroxenites (p. 155.)

Mineralogical Composition. Varieties. The most abundant mineral in these rocks is naturally hornblende. With it are associated oftentimes biotite, augite, plagioclase, garnet, magnetite, pyrite and pyrrhotite; but quartz except as forming veinlets is not often met nor is it to be expected in such basic rocks. The commonest variety of hornblende is black to the eye but is green in thin section. It forms prismatic crystals from moderately coarse to microscopically fine. The prisms are interlaced so as to make a very tough aggregate and one that breaks with difficulty under the hammer. Light green actinolite may also form schists. Black scales of biotite appear interlaminated with the hornblende. The augite is not readily distinguished from the hornblende with the eye alone. It is in large degree the remnants of original pyroxenes that have partially passed into hornblende during the metamorphic process. The plagioclase also represents to a great extent the feldspar that was in the original gabbro or other igneous rock from which the amphibolite has been derived. The plagioclase is often replaced by secondary products, such as epidote, calcite, scapolite and others, which together make up the aggregate formerly called saussurite and regarded as an individual mineral. The minor accessories magnetite, pyrite, pyrrhotite and garnet deserve no special mention. Except magnetite, which never fails, they are of more or less irregular occurrence.

Alteration. The hornblende passes readily into chlorite and softens to a scaly mass with the separation of much limonite that yields a characteristic, rusty outcrop. If any pyrite or pyrrhotite is present it greatly expedites the alteration by its contri-

bution of sulphuric acid. The feldspars yield calcite and kaolin and the whole mass becomes a rusty clay or soil.

Occurrence. The hornblende-schists constitute individual belts in schistose regions in the midst of other metamorphic rocks and also great areas by themselves. Dikes and sheets of diabase and plutonic masses of gabbro in districts that have been subjected to violent dynamic upheavals readily pass into them. The same areas in the Eastern States that were cited under gabbro contain them, and they are minor members in the schistose districts of New England. Around Lake Superior they form a most important part of the geology of the iron ore regions, and in the Black Hills, the Rocky Mountains and the ranges of California they are often met.

Various Minor Schists.

Under this collective term are assembled a series of minor rocks, no one of which compares in importance with the schists already mentioned, but which may be met as subordinate members of metamorphic districts. There are also others in considerably variety which are esteemed too unimportant for an elementary book.

	SiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	CaO.	MgO.	K_2O.	Na_2O.	H_2O.
Chlorite schist.									
1.	49.18	15.09	12.90		10.59	5.22	1.51	3.64	1.87
2.	47.10	2.14	44.33		0.36	0.13			5.19
Talc schist.									
3.	58.66	9.26	4.42		0.94	22.78			4.09
4.	50.81	4.53	3.52	4.26		31.55			4.42
Epidote schist.									
5.	41.28	18.48	9.44	8.20	7.04	7.48	2.21	3.52	2.74
Eclogite.									
6.	48.89	14.46	2.00	7.15	13.76	12.21	0.17	1.75	.40
Glaucophane schist.									
7.	47.84	16.88	4.99	5.56	11.15	7.89	0.46	3.20	1.98

1. Chlorite schist, Klippe, Sweden, Cronqvist for Törnebohn. Quoted by Roth, *Gesteinsanalysen*, 1884, p. VIII. 2. Chlorite schist, Foster Mine, Mich., C. F. Chandler, *Geol. of Mich.* I, 91. 3. Talc schist, Fahlun, Sweden, Uhde quoted by Roth, *Gesteinsanalysen*, 1861, 56. 4. Talc schist, Gastein, Austria, R. Richter, *Idem.* 5. Epidote schist from diabase, South Mountain, Pa., C. H. Henderson, *Trans. Amer. Inst. Min. Eng.*, XII, 82. 6. Eclogite, Altenburg, Austria, Schuster *Tscher. Mitt*, 1878, 368. 7. Glaucophane schist, Monte Diablo, Calif., W. H. Melville, *Bull. Geol. Amer.* II, 413.

Comments on the Analyses. These analyses are too variable to admit of much in the way of comparative remarks, for the rocks are so totally unlike. No. 1 suggests an original diabase or some such rock. No. 2 is abnormally rich in iron, doubtless in large part from magnetite or hematite. The high magnesia in Nos. 3 and 4 is characteristic and indicates their close relations with serpentines. No. 5 is an altered diabase. No. 6 is of a rock variable in its mineralogy and obscure in its history. No. 7 is practically a hornblende-schist with glaucophane, an amphibole that is high in soda, instead of common hornblende.

Mineralogical Composition, Varieties. The chlorite schists are marked by the presence of this green micaceous mineral in large amount. More or less quartz is also generally present, and not infrequently plagioclase, talc, epidote and magnetite. The schistose texture is pronounced. The chlorite-schists are manifestly alteration products from some rock, with abundant anhydrous, iron-alumina silicates. Hornblende-schists, presumably from basic igneous rocks are the general source. Certain chlorite-schists are often called "green schists."

Talc-schists are characterized by sufficient talc to make this mineral prominent and in addition they have quartz as the next most abundant constituent. Feldspar may at times be noted, and some micaceous mineral is not rare. Care is necessary not to confuse fine scales of the last named with talc itself. Various accessory minerals likewise occur, and the magnesian carbonates, dolomite and magnetite are often present. Obviously the talc-schists have resulted from the alteration of some rock with one or more anhydrous magnesian silicates that lacked iron. Tremolite and enstatite are the most available, but the original sources of these are often obscure. Siliceous dolomites or intrusive pyroxenites at once suggest themselves, but the iron must of necessity have been low, so as not to yield serpentines.

Epidote-schists result when the ferro-magnesian silicates and the plagioclases are so favorably situated with reference to each other as to establish mutual reactions. They especially arise as phases in the metamorphism of pyroxenic or hornblendic rocks, such as diabase, hornblende-schists and the like. Eclogite is a rock scarcely known in America, having, as yet, only been noted near the Washington Mine, Marquette District, Mich. (Geol. of Wis., III, 649). It is a well recognized variety, however, in Europe. It consists of

bright green amphiboles and pyroxene, of garnet and of a variety of minor minerals. In ordinary determination it would not be distinguished from a garnetiferous, actinolite schist. Glaucophane is a blue soda amphibole that is rare in America, except in the coast range of California, where it characterizes certain important schists. The rocks have a pronounced blue shade, and contain in addition quartz and feldspar. In California they certainly are altered shales. Graphite appears quite commonly as a characteristic mineral of certain schists, and may justify the use of the name graphite schist. More or less mica, and always quartz and feldspar are associated.

Distribution.—Chlorite-schist and talc-schist are not uncommon members of our larger metamorphic series, especially along the Appalachians, in New England and around Lake Superior. Epidote-schist is less common in the same relations. The occurrence of eclogite and glaucophane-schist has already been cited. Graphite-schist is not infrequent in the metamorphosed Paleozoic strata of the East.

CHAPTER XI. THE METAMORPHIC ROCKS, CONTINUED. THE ROCKS PRODUCED BY REGIONAL METAMORPHISM. THE QUARTZITES AND SLATES. THE CRYSTALLINE LIMESTONES AND DOLOMITES, OPHICALCITES, SERPENTINES AND SOAPSTONES.

THE QUARTZITES.

	SiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	CaO.	MgO.	K_2O.	Na_2O.	H_2O.	Sp. Gr.
1.	97.1	1.39	1.25		0.18	0.13				
2.	96.44	1.74		0.33	0.17	0.22	0.13	0.19	0.90	
3.	84.52	12.33		2.12	0.31	tr.	0.11	0.34	2.31	2.74

1. Quartzite, Chickies Station, Penn.,* *Penn. Geol. Surv. Rep. M.* p. 91. 2. Sandstone partly altered to Quartzite, Quarry Mtn. Ark., R. N. Brackett for L. S. Grisswold, *Geol. of Ark.* 1890, III, 140, 161. 3. Quartzite, Pipestone, Minn. W. A. Noyes in *Minn. Geol. Surv.* I, 198.

Comments on the Analyses. There is no essential difference in the analyses of quartzites and sandstones, as the few quoted above

*By a mistake in copying, somewhat justified by the arrangement in Report M., an analysis of a damourite slate was quoted on p. 278, No. 1, as this quartzite. The error is noted in the Errata, p. 401.

will show, but doubtless the resulting quartzite is somewhat richer in silica than the original sandstone. Comparatively few analyses of quartzites have been made in America.

Mineralogical Composition, Varieties. The quartzites are metamorphosed sandstones, and differ from the latter principally in their greater hardness, and to a certain extent in their fairly pronounced crystalline character. These qualities are due to the presence of an abundant siliceous cement that is crystalline quartz, and that is often deposited around the grains of quartz of the original sandstone, so as to continue their physical and optical properties. The original grains have, therefore, had the power of controlling the orientation of the molecules of the new silica as it crystallized. When the original sandstone has been argillaceous the resulting quartzite contains mica and especially muscovite, and with increase of the mica, such quartzites pass through the intermediate varieties of quartz-schist into mica-schists. A very curious and more or less micaceous variety is the so-called flexible sandstone or itacolumite, whose grains have the power of slight movement on one another from their loosely interlocked arrangement so that thin slabs may be bent through a considerable arc. Quartzites also result from pebbly sandstones and conglomerates, and the pebbles of these latter are often flattened by the dynamic movements with which the metamorphism is at times associated. There is no sharp line of demarcation between quartzites and sandstones, and while the extremes of soft sandstones and hard quartzites are entirely different, the determination of intermediate varieties is more or less arbitrary.

Alteration. Quartzites sometimes soften to sand on their outcrops, and in the process, almost the last vestiges of alumina or lime may be removed. In this way the sands in analysis No. 1, p. 275, were formed. In general, however, they are excessively resistant rocks, and tend to form prominent ledges.

Distribution. Quartzites occur in almost all series of metamorphosed sediments, and as these are best developed in the later Archean, (Huronian, Algonkian) strata, they especially characterize them. In the metamorphic belt in New England and down to the southern Appalachians, they are frequent, as well as in the Huronian, around Lake Superior and Lake Huron and in the similar areas of the West.

THE SLATES.

	SiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	CaO.	MgO.	K_2O.	Na_2O.	H_2O.
1.	66.45	13.38	1.71	1.41	2.86.	6.28	0.05	0.90	4.03
2.	66 00		24.60		tr.	tr.	3.67	2.22	3.00
3.	65.85	16.65	. .	53.1	0.59	2.95	3.74	1.31	3.10
4.	64.57	17.30	7.46		1.16	2.60	1.99	. .	4.62
5.	63.31	16.16	3.79		0.15	4.44	7.56	1.54	2.65
6.	60.50	19.70		7.83	1.12	2.20	3.18	2.20	3.30
7.	60.32	23.10	7.05		. .	0.87	3.83	0.49	4.08
8.	57.00	20.10		10.98	1.23	3.39	1.73	1.30	4.40
9.	55.88	21.85		9.03	0.16	1.49	3.64	0.46	3.39
10.	54.80	23.15		9.58	1.06	2.16	3.37	2.22	3.90

1. Slate Llanberis, Wales. Quoted by G. P. Merrill, *Stones for Building and Decoration*, p. 421, also MnO, 0.91, CO_2, 1.30. 2. Slate, Etchemin Riv. N. B., T. S. Hunt, *Phil. Mag.* (4) VII, 237, 1854. 3. Roofing slate, Westbury, Can., *Idem.* 4. Roofing slate, Lehesten, Germany. Frick, quoted by Roth, *Gesteinsanalysen*, 1861, p. 57. 5. Damourite slate, Hensingerville, Pa., *Geol. of Penn. Rep. M.* 91. Note.—This analysis was misquoted as an argillaceous sandstone on p. 278, to which, however, it corresponds quite well in composition. 6. Roofing slate, Wales, T. S. Hunt as under No. 2. 7. Slate, Lancaster Co., Penn., also FeS_2 0.09. See under No. 1, 8, Roofing slate, Angers, France, T. S. Hunt, as under No. 2. 9. Blue-black carbonaceous slate, Peach Bottom slate, York Co., Penn., also MnO., 0.586, CoO. tr. C. 1.974, FeS_2, 0.51, SO_3, 0.022. See under No. 1, 10, Roofing slate, Kingsey, Quebec, T. S. Hunt, as under No. 2.

Comments on the Analyses. These analyses are especialiy significant when compared with those of the shales and clays, p. 278, and with those of the mica-schists, p——, with which latter they are closely parallel. Two features at once impress the observer, the excess of magnesia over lime, and the excess of potash over soda. The former stamps their origin as from sediments rather than from igneous rocks of these percentages in silica, because this relative excess of magnesia as noted under the mica-schists is rather characteristic of sediments.

Mineralogical Composition. Varieties. As the sandstones during metamorphism pass into quartzites, so the shales and clays become slates, when not so thoroughly recrystallized as to yield mica-schists or phyllites. The more sandy shales afford varieties that break irregularly and that lack homogeneity, but tough and even slates result from homogeneous clays and are among the most remarkable of rocks. The distinctive feature of slates as against shales is the possession of a new cleavage that may lie at any angle with the original bedding of the rock; and that has no definite relation to it. The cleavage has been developed by dynamic

strains that have, beyond question, involved a shearing stress and, some differential movement among the layers, though it may have been microscopic. As a matter of observation the component grains of slates have became flattened and lie parallel with the new cleavage, and any mica flakes or hornblende needles that may be present lie along it.

Various explanations have been advanced for slaty cleavage, and its artificial production in different substances has occupied several investigators. Based principally upon experiments performed by Professor John Tyndall, over forty years ago, it has been usually referred to a compressive force at right angles to its plane. Tyndall subjected blocks of wax to pressure, using wet glass plates as his buttress of resistance. The blocks were of course greatly reduced in thickness and were force to spread or bulge laterally. Shortly afterward H. C. Sorby, partly on the basis of the flattening of the component grains, and the alignment of mica scales, explained the cleavage as due to planes of weakness caused by this new arrangement. Recently, G. F. Becker of the U. S. Geological Survey has repeated the experiments of Tyndall with modifications. So long as the resisting glass plates were wet with water the slaty cleavage was developed, but when they were smeared with a heavy lubricating oil, although there was lateral expansion during compression, no bulging took place and no cleavage was developed. Manifestly therefore the frictional drag of the plates enters into the problem, and although the resolution of the forces involved is somewhat complex, a shearing stress results that is a strong factor in producing the cleavage.* In the case of the large beds or strata which are metamorphosed into slate in Nature, the case is even less simple, and the contrasts in rigidity, between the beds that yield slates and their enclosing strata, are less pronounced than in the experiment, but there is little doubt that the compression and lateral flow with their attendant strains, occasion the cleavage, and that the flattening of the grains and alignment of the scaly minerals are attendant phenomena. All slates have cross-cleavages, also, more or less well developed, and one of these may even be perfect enough to cause the slate to break into small prisms available for slate pencils, for which in earlier years they were employed. All slate-quarries also show curly slates, where quartz-veins or

*G. F. Becker Finite homogeneous Strain, Flow and Rupture in Rocks, *Bull. Geol Soc. Amer.* IV, 82, 1893.

sandy and harder streaks in the original sediment have caused imperfections in the cleavage. It has also been noted that in some quarries the available plates appear to become thicker in depth, as if the surface weathering had been a factor in developing the cleavages. Though commonly drab to black, they may be red, green or purple.

Slates pass by all intermediate gradations into phyllites and mica-schists. The word slate is also loosely used for shales, that have never had any secondary cleavage induced in them, and this is especially true of the black, bituminous shales that occur with coal seams, but in strict, geological use, the new cleavage and metamorphism should be an essential of a true slate.

Alteration. Slates are exceedingly resistant as is shown by their use in thin slabs for roofs, and they often constitute prominent ledges or even peaks. They soften down to a clay in the last stages of alteration, but always on the outcrop are more tender than in depth, so that much dead work is unavoidable in opening quarries.

Distribution. Our most prominent slates are Cambrian or Ordovician in age. Along the Green Mountains and especially in northern Vermont they are strongly developed. Again in eastern Pennsylvania, in Virginia and in Georgia they are met in great areas. On the south shore of Lake Superior merchantable grades have been somewhat developed. Along the western slopes of the Sierra Nevada Mountains they are a very important rock.

THE CRYSTALLINE LIMESTONES AND DOLOMITES.

	$CaCO_3$.	$MgCO_3$.	SiO_2.	Al_2O_3.	Fe_2O_3. FeO.	Insol.	Loss. or H_2O.
1.	99.51					0.29	0.20
2.	99.24	0.28					
3.	98.43	0.30			0.31	0.38	0.15
4.	98.21	2.35			0.15	0.35	
5.	98.00					0.57	1.63
6.	96.82	1.89			0.10	2.12	
7.	92.42	6.47			0.35	0.95	
8.	70.1	25.40				2.40	
9.	54.62	45.04	0.10		0.7		
10.	54.25	44.45				0.60	

1. Statuary Marble, Brandon, Vt. Quoted by G. P. Merrill, *Stones for Building and Decoration*, 417. 2. Marble, Carrara, Italy, *Idem.* 3. Marble, Knoxville, Tenn., *Idem*, also S, 0.014, Organic Matter 0.068. 4. Coarse-grained black and white mottled Marble, Pickens Co., Ga., locally called Creole; *Geol. Surv. Ga., Bulletin* I, 87. 5. White Marble, Rutland, Vt., see under No. 1. 6. Coarsely crystal-

line white Marble, Cherokee Quarry, Pickens Co., Ga., see under No. 4. 7. White Crystalline Limestone, Franklin Furnace, N. J., Geo. C. Stone, unpublished. 8. Crystalline Magnesian Limestone, Tuckahoe, N. Y., H. L. Bowker for Lime Co. 9. Crystalline Dolomite, so-called "Snowflake Marble," XVI. *Ann. Rep. Div. U. S. Geol. Survey*, Article "Stone," Reprint p. 41. 10. Crystalline Dolomite, white Marble, Inyo Co., Calif., *Ann. Rep. Calif. State Mineralogist, 218.*

Comments on the Analyses. The analyses do not differ essentially from those of unaltered limestones except so far as the ones in the table are purer carbonates of lime and magnesia. The available analyses are of merchantable marbles, and in the nature of the case these are derived from very pure sedimentary limestones. They are interesting as illustrating the series from almost chemically pure carbonate of lime to one in which the carbonate of magnesia reaches the values of typical dolomite. Comparison with the analyses of limestones earlier given, on p. 282, is recommended. It will be seen that in this case there is apparently no change in gross composition from metamorphism, but of course the relations of the silica and the bases are different. In the sedimentary limestones the silica is largely in the form of quartz and in combination with alumina forming hydrated silicates, such as kaolin. In the crystalline limestones it is largely in silicates of lime, magnesia and alumina, such as tremolite, pyroxene, phlogopite, etc., minerals whose formation has been one of the results of metamorphism. The percentages in the insoluble column do not therefore indicate pure silica. There may be even microscopic barite crystals present.

Mineralogical Composition. Varieties. The crystalline limestones and dolomites are metamorphosed forms of the sedimentary varieties earlier described. The change involved is, as the name implies, one of crystallization. Fossils, and to a large degree bedding planes, are destroyed and a more massive aggregate of calcite or dolomite crystals results. Such carbonaceous material as was originally present usually affords streaks of graphite which occasion dark veinings. They bring out the brecciation or flow-lines induced by the pressure from the mountain-making upheavals usually attendant on the metamorphism. Other bituminous or ferruginous matter may yield pronounced colors of many hues.

If the original limestone has been an impure variety and has contained silica, alumina and iron oxides, as illustrated by the analyses on pp. 282, 283, these components have furnished the necessary materials for various silicates that the metamorphism

has caused to form. Tremolite is a common result, light-colored pyroxenes are not infrequent, and phlogopite or other micaceous minerals are the most abundant of all. Large quarries always show borders or streaks that are characterized by these minerals, and where the original limestone passed into shales or sandstones at its upper and under surface, these micaceous varieties are almost always met. For ornamental purposes the included silicates, being except in the case of micas, of greater hardness than the calcite, serve to mar the stone.

Crystalline limestones form more or less extensive strata in the midst of other metamorphic rocks. Slates, phyllites, mica-schists and quartzites are their most common associates. The dolomites may have formed in many cases from pure calcareous limestones by the infiltration of magnesian solutions, and by an exchange of a portion of the magnesia for a portion of the lime, as earlier referred to on page 284, but so many unaltered limestones are high in magnesia, that the change is not a necessary attendant of metamorphism.

Alteration. Crystalline limestones are soluble rocks and weather with comparative facility. Where they occur in metamorphic belts they are invariably in the valleys, and are potent factors in determining the direction of the drainage lines. Where exposed for long periods they afford a coarse, crumbling sand or gravel, that is much used for roads in the borders of the Adirondacks and in western New England. The final stage is a mantle of residual clay from which the calcareous material has been largely leached.

Occurrence. The crystalline limestones are frequent in our metamorphic districts. In the Appalachian belt they are of great areal and economic importance, and are largely quarried in Vermont, Massachusetts, New York, Pennsylvania and Georgia. In western Colorado they are strongly developed, and in the Sierras of California the same is true, Inyo County being a rather large producer of marble. The foreign mountainous and metamorphic districts exhibit enormous exposures. The great series of ranges that begin in the Pyrenees and extend through the Alps and the Carpathians to the Himalayas, have many famous quarries and ledges. The region of the "Dolomites" in the Tyrolese Alps is a district of especial richness. The Carrara marble of the Appenines, the Pentelic of Greece and the colored varieties from Northern Africa, indicate their presence in those regions.

THE OPHICALCITES, SERPENTINES AND SOAPSTONES.

Ophicalc.	$CaCO_3$.	$MgCO_3$.	$FeCO_3$.	SiO_2.	MgO.	H_2O.	FeO.	Al_2O_3.
1.	57.37	9.64	0.74	13.18	10.29	4.06	3.57	0.85
2.	23.85	22.28	1.97	22.42	18.74	6.43	4.30	
3.	7.65	10.98	1.78	36.53	28.08	8.63	6.49	

Serp.	SiO_2.	MgO.	H_2O.	Al_2O_3.	Cr_2O_3	Fe_2O_3.	FeO.	NiO.	CaO.
4.	44.14	42.97	12.89						
5.	43.87	38.62	9.55	0.31			7.17	0.27	0.02
6.	42.52	42.16	14.22			1.96			
7.	41.54	40.42	14.17	2.48			1.37	0.04	
8.	40.67	32.61	12.77	5.13			8.12		
9.	40.06	39 02	12.10	1.37	0.20		3.43	0.71	
10.	36.95	33.07	10.40			16.50			
11.	34.84	30.74	17.39	0.42	0.68	6.08	1.85	tr.	7.02
Soapst.									MnO.
12.	64.44	33.19	0.34	0.48			1.39	0.23	
13.	62.10	32.40	2.05				1.30		2.15
14.	62.00	33.1	4.9						

1. Ophicalcite, Oxford, Quebec, T. S. Hunt, *Amer. Jour. Sci.*, March, 1858, 220. The analysis as cited is assembled from several partial analyses. 2. Ophicalcite, Brompton Lake, Quebec, *Idem*, p. 221. Original results recast as in No. 1. 3. Ophicalcite, Brompton Lake, Quebec, *Idem*, p. 222. Recast as before. 4. Theoretical serpentine, $H_4Mg_3SiO_9$. 5. Massive serpentine, Webster, N. C., F. A. Genth, *Amer. Jour. Sc.*, II, xxxiii, 201. 6. Massive serpentine, Montville, N. J., E. A. Manice, *Dana's Mineralogy*, 1877, 467. 7. Serpentine, a metamorphosed sandstone, New Idria, Calif., W. H. Melville for G. H. Becker, in *Monograph, XIII., U. S. Geol. Surv.*, 110. 8. Serpentine, decomposed peridotite, Syracuse, N. Y., T. S. Hunt, *Amer. Jour. Sci.*, Sept., 1858, 237. 9. Serpentine, Dublin, Harford Co., Md. Quoted by G. P. Merrill, *Stones for Building and Decoration*, 414. 10. Serpentine from peridotite, Presq' Isle, Mich., J. D. Whitney, *Amer. Jour. Sci.*, II., xxviii., 18, also Na_2O, 0.97. 11. Serpentine, from peridotite, Monte Diablo, Calif., W. H. Melville, Bull. Geol. Soc. Amer., II., 408, also Na_2O, 0.42, K_2O, 0.07. 12. Soapstone, Webster, Jackson Co., N. C., F. A. Genth, *Minerals of North Carolina*, p. 61. 13. Talc, Gouverneur, N. Y., Analysis quoted by C. H. Smyth, Jr., *Sch. of Mines Quarterly*, July, 1896, p. 340. 14. Theoretical talc, $6MgO, 5SiO_2, 2H_2O$.

Comments on the Analyses. The ophicalcites mark a passage from the dolomites to the serpentines. They are practically crystalline magnesian limestones or dolomites, that are mottled with inclusions of serpentine in varying amounts. The analyses begin with one that is over half calcite and over two-thirds calcite and dolomite. The ratios of the remaining oxides are just about those required by serpentine. In the second the amount of serpentine has much increased and in the third the carbonates have notably retreated. Under the serpentines, as compared with the theoretical mineral, No. 4, the succeeding analyses are all notably rich in iron. Except in the cases of Nos. 10 and 11, they are remarkably uni-

form considering their diverse origin. In No. 10 the SiO_2 drops, probably from the presence of magnetite while in the last the pyroxene of the original peridotite has contributed considerable lime. In all these rocks Al_2O_3 is notably low. It is most abundant in No. 8, a serpentine that is derived from a rock with much augite. Chromium is a rather characteristic element in serpentines that result from basic igneous rocks, and nickel can be very generally detected on analysis. Lime practically fails except in No. 11. It should be appreciated that as a mineral, serpentine is a unisilicate, whereas talc is a bisilicate, and this explains the much larger percentage of silica in the latter. The soapstones are fairly pure, aggregates of talc, as a comparison of Nos. 12 and 13 with No. 14 will indicate.

Mineralogical Composition. Varieties. The ophicalcites are mottled rocks consisting of irregular or rounded masses of green serpentine embedded in white calcite and dolomite. The proportions of the constituent minerals are variable. The serpentine may be in small nodules a fraction of an inch in diameter or in large stringers and masses several feet across. This irregularity renders it difficult in quarrying to preserve a uniform grade. The stone is mottled green and white, and when uniform is a very beautiful one. The serpentine varies from dark green or almost black, to light clear shades, and has been derived in a number of cases, as has been shown by G. P. Merrill,* from original pyroxene crystals. The ophicalcites are therefore in many cases alteration products from a crystalline limestone, that has been surcharged with pyroxenes, and this itself may probably be referred in most cases to an original siliceous, magnesian sediment, recrystallized by regional metamorphism.

Ophicalcites are also called ophiolites, serpentinous marbles and verd antique. The syllable "ophi," in all these words is derived from the Greek for serpent and ophicalcite means therefore a serpentinous limestone.

The serpentines are green or red aggregates of scales, fibres or massive individuals of the mineral serpentine. They display considerable variety of texture according to the characters of these components. Other minerals are not especially prominent. Grains of chromite or magnetite may be detected and garnets of the

*G. P. Merrill, *Amer. Jour. Sci.*, March, 1889; *Proc. U. S. Nat'l. Museum*, XII, 595, 1890.

variety pyrope are sometimes well developed. Veinlets of calcite or of magnesian carbonates ramify through the rock in many exposures. Remains of the original olivine, pyroxene, or hornblende from which the serpentine has been derived may often be detected and biotite or some hydrated magnesian mica is not infrequent. The varieties of the mineral serpentine are numerous, but many of them are too rare to be serious rock-makers. Almost all serpentines have been formed by the alteration of basic igneous rocks, among which the pyroxenites and peridotites are the chief contributors. Hornblende schists also yield them and G. F. Becker has recorded the remarkable case of sandstones that pass into them in the Coast Ranges of California.

Soapstone, called also steatites, are chiefly talc as the analyses show. Quartz veinlets often run through the rock and scattered grains of quartz are not infrequent. Magnesian carbonates are likewise evident in many exposures. In the case of the Gouverneur beds of talc (see Anal. 13), C. H. Smyth has shown that the original minerals have been tremolite and enstatite, and that the beds occur in crystalline limestone, but from what the tremolite and enstatite have been derived is a hard problem. Two reasonable sources suggest themselves, either a siliceous dolomite, or a non-ferruginous, basic intrusive. The soapstones are not particularly abundant rocks but are of economic value where met. They are close relatives of the talc schists earlier cited.

Alteration. The serpentinous rocks themselves are thoroughly altered derivatives from fresher anhydrous ones and in their further decomposition simply soften to incoherent dirt and clay. The more resistant, included minerals are thus set free, and as in the case of platinum and garnets they may be concentrated in gravel.

Distribution. Ophicalcites are most abundant in Quebec, the northern Green Mountains and the foothills of the Adirondacks. The serpentines are especially notable on Staten Island, in southeastern Pennsylvania and the neighboring parts of Maryland, where the gabbros, as stated on p. 159, and their related rocks are abundant. They share in an important belt of these basic intrusives in North Carolina and Georgia. In the basic igneous rocks around Lake Superior, they are occasionally met as alteration products. In the Coast ranges the serpentines are of very great importance, and in part are altered sediments. They are likewise common abroad, and in a minor capacity appear in many metamorphic districts.

Soapstone is much less common, but is met in this country as a minor member in much the same regions as the serpentines and crystalline dolomites.

Chapter XII. The Metamorphic Rocks, Concluded. The Rocks Produced by Atmospheric Weathering. The Determination of the Metamorphic Rocks.

Introduction. It is a matter of common observation that outcrops of rock and loose boulders are always more or less decomposed and broken down or "weathered" for a greater or less distance below their surfaces. This may not be serious enough to prevent the accurate recognition of the rock, and usually within the area once covered by the great ice sheet of the Glacial Period it is not, because the moving ice ploughed away all loose and decomposed materials, but south of the terminal moraine, and above all in the tropics, the decomposition is excessive and may produce to a depth of a hundred feet or more a mass of alteration products that give of themselves slight, if any, clue to their originals. This is a common experience in the Southern States, where, as well as in Central and South America, the indefinite character of the surface rock throws great difficulties in the way of accurate geological mapping. So difficult at times is the determination of the country rock that, for example, during field work in Brazil, O. A. Derby has felt compelled to resort to the panning out of the surface materials with a gold-seeker's pan in order, by concentrating the heavy but small and undecomposed accessory minerals, such as zircon, titanite, monazite, xenotime, apatite and others, to get some clue from their characteristic associations to the original rock. Many travelers have noted the brilliant colors of the soils of latitudes toward the equator and the comparatively somber tones of those toward the poles.

These products of weathering are so widespread, therefore, and so individual that a few pages have been reserved for their particular mention. Special names for them have been suggested at various times. The oldest one and the one most current is laterite. The word means brick earth and was originally applied to the red or brown ironstained surface soils occurring in the tropical lands, and derived by direct decomposition from the country rock in place. It has been applied in later years, however, to all sorts of these sur-

face soils from whatever rocks derived, and whether colored red or not. G. F. Becker, of the U. S. Geological Survey, has recently (1895) proposed saprolite,* a word meaning literally rotten rock, as "a general name for thoroughly decomposed, earthy, but untransported rock." This is practically the modern use of laterite, although it is broader than the latter's original application. The U. S Geological Survey in the invaluable series of atlas sheets now being issued employs the term "surficial," *i. e.*, surface rocks, as a general designation for these untransported products of decomposition. We also often speak of residual clay as was done on pp. 278 and 280 for the less soluble aluminous residues left behind in the removal of the more soluble portions of limestones.

The general scope and application of these names having been set forth, a brief consideration will be given to the mineralogical processes of change that have bought them about from several of the commoner groups of rock.

The chief causes of this superficial breaking down or "degeneration," as it has been aptly called by G. P. Merrill,† are the chemical action of rain and ground waters, especially when charged with carbonic acid or other dissolved matter; organic life, both vegetable and animal, operating through the agency of the organic acids produced by their living processes or by their decomposing remains; and the mechanical disintegration produced by changes of temperature, by the freezing of water and by swelling from hydration or from some of the chemical or mineralogical changes among those referred to above. Although having no connection with these atmospheric processes, yet hot springs and allied exhalations from dying volcanic activity bring about closely similar results and are able to change great sheets of volcanic rock to brilliantly variegated masses of clay and kaolin. At the Falls of the Yellowstone River, in the National Park, these are wonderfully and impressively displayed, more than a thousand feet of rhyolite having been changed practically to kaolin.

Under the action of the chemical agents the more easily soluble elements are removed or are put in such relations to one another as to facilitate their rearrangement in new and secondary combinations. In the rocks composed of silicates the most vulnerable oxides are lime, magnesia, potash and soda. Iron oxides also

*Goldfields of the Southern Appalachians, p. 43, XVI. *Ann. Rep. Dir. U. S. Geol. Survey.*

† Bulletin of the Geological Society of America, VII., 378.

suffer extensively, but the ferric form is sometimes very resistant. Silica yields more or less, especially to the alkaline solutions from the potash and soda referred to above. Alumina, on the whole, is least readily attacked of all, and is usually the one that furnishes the best basis of comparison between analyses of altered and unaltered materials.

Among the igneous and metamorphic rocks open or porous varieties naturally suffer more than compact and finely crystalline ones. Rocks high in the bases that are most readily attacked chemically are easier victims than those especially rich in the resistant ones. Basic rocks, therefore, with their high percentages of lime and magnesia and their relatively low silica, suffer especially, whereas granites and related gneisses are much more stubborn subjects, the large amount of quartz in them furnishing a very resistant component.

Granites, syenites, acid diorites and their corresponding porphyritic types alter especially through the feldspathic member present. The constitueut quartz is but slightly affected, and the dark silicates are not present in sufficiently large amounts to be very serious factors. The resulting product is a kaolinized or clayey mass through which are distributed quartz grains, and which is more or less stained by the hydrated oxide of iron that is yielded to some extent by the dark silicates. The characteristic products of the latter are also present in small amounts, but are more extensively mentioned subsequently. The exposed ledges furnish loose pieces that often weather in concentric shells and simulate rounded waterworn boulders. The net result is a large contribution of clay and sand to sedimentary or eolian deposits it may be at a great distance.

In the basic igneous or metamorphic rocks the dark ferro-magnesian and aluminous silicates are in excess, and in decomposition their peculiar products predominate. The distinctively magnesian ones yield serpentine, the aluminous change to chlorite. Both these minerals are prevailingly green, and dark green surficial rocks result. The abundance of iron in them leads to the formation of very rusty outcrops.

In the case of limestone, the lime and magnesia are dissolved away, while the alumina, silica and iron oxides remain behind in the mantle of impure residual clay already referred to; the other sedimentary rocks suffer especially from mechanical processes, although chemical changes are not lacking among them, for, as re-

marked on page 422 regarding analysis No. 1, of page 275, during the breaking up considerable leaching may result that leads to the production of nearly chemically pure quartz sand.

The mechanical and associated chemical breaking down of rocks tends to place them in more favorable conditions for further chemical alterations, and for erosion and removal.

All the changes in the weathering of rocks have been well described by M. E. Wadsworth as "resulting from the general dissipation and degradation of the potential energy of the constituents of the earth's crust in the universal passage of matter from an active state towards a passive and inert condition."*

The Determination of the Metamorphic Rocks.

The rocks resulting from contact metamorphism are rather of local interest, than of wide, areal distribution. The spotted schists and slates, and the hornstones are readily recognized by a practiced observer. The crystalline limestones even when charged with silicates may closely resemble the products of regional metamorphism. In dealing with the latter, familiarity with well characterized types is the safest guide. The gneisses are at once apparent from their laminated character and granitoid texture. Transition members between them and the mica-schists on the one hand, and the hornblende-schists on the other, may cause hesitation as to which group they belong to. The finely laminated ones are certainly members of the schists, those with prevailing mica belonging with the mica-schists, those with prevailing hornblende, with the hornblende-schists. Again as the fineness of the lamination or foliation increases, the schists pass into the phyllites and slates, that are easily recognized. The quartzites likewise present little difficulty as they are practically hard sandstones. The crystalline limestones and dolomites are only to be distinguished by the ease or difficulty of obtaining effervescence. The ophicalcites look like no other rocks, and the serpentines and soapstones are also at once apparent. The soapy feel of all these magnesian rocks aids in their recognition. There are, of course, rare and obscure metamorphic rocks that cause trouble, but such, just as in the case of the finely crystalline igneous rocks, are best referred to someone familiar with the use of the microscope.

*The Theories of Ore Deposits, *Proc. Bost. Soc. Nat. Hist.* Vol. XXIII., p. 202. 1884.

OPTICAL MINERALOGY.*

By LEA McI. LUQUER, Ph.D.

Introduction.

The accurate determination of rocks, by means of the microscopic investigation of thin sections, has become a matter of importance to many classes of professional men, as well as to the expert petrographer. The microscope has come to the aid of the investigator within comparatively recent times, and has enabled him to make great advances in exact knowledge of petrography. As rocks are often aggregates of minerals, the determination of a rock depends chiefly on the recognition and identification of its mineral constituents, taken in connection with pecularities of structure, etc. It will be found that the practical knowledge actually required to determine most of the common rock forming minerals, and to recognize the more ordinary types of rocks, is not so very extensive. At the same time it is equally true that, just so soon as the determination of the rarer minerals and types of rocks is attempted, the difficulties of investigation are greatly increased, and should only be attempted by experts.

A knowledge of optics, physical crystallography and the optical characters of minerals is required for all optical investigations. These branches of science are usually difficult for busy professional men to acquire, on account of the elaborate and highly technical character of most of the literature on these subjects. In many cases the books are in German and are quite expensive.

Mining engineers, civil engineers, architects and builders are all more or less interested in rocks and building stones, and may, perhaps, appreciate this simple introduction to the knowledge necessary for the practical investigation of rocks by means of the microscope. This short article, in three parts, will include a few notes on elementary optics, a description of a simple form of petrographical microscope, and the method of investigating the optical properties or characters of minerals. An elementary knowledge of mineralogy, including crystallography, is assumed.

It is impossible in this paper to give a detailed description of the optical characters of minerals; but, in order to aid in the

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practical application of the principles herein contained, *i. e.*, the actual recognition of minerals in rock-sections, the writer refers to an article on "The Optical Recognition and the Economic Importance of the Common Minerals found in Building Stones," published by him in this Journal, Vol. XV., p. 285, July, 1894. This article necessarily left out many minerals and facts important petrographically, but not so much so in the case of building stones. Still with the use of this introduction to the subject and the optical characters of minerals, given in Vol. XV., the investigator should be able to recognize the majority of the common minerals.

PART I.

INTRODUCTORY OPTICS FOR OPTICAL MINERALOGY.

As the object of this introduction is merely to give a practical, elementary knowledge of optics, as applied to optical mineralogy,* no elaborate discussion of this important subject will be attempted. The explanations will be made as simple as possible, and, in most cases, only the optical phenomena will be described without entering into a theoretical discussion as to the cause of these phenomena.

Light is transmitted by wave motion, of the "luminiferous ether," taking place at right angles to the direction of transmission.

Ordinary light is light with the wave vibrations in all possible azimuths or planes.

Polarized light is simply light with the wave vibrations all *parallel* to one plane.

By experiments it has been proved that there exists a very close relation between the optical properties of crystals and their other physical properties such as form, color, transmission of heat, etc. Therefore it is often possible by a careful optical investigation of a crystal section to determine important crystallographic facts, even in the absence of any distinct outline.

The Effects Produced by Crystals on Transmitted Light.

In dealing with this subject, imagine for convenience the material part of a crystal and the etherial part (*i. e.*, the part which

* For a complete discussion of optics, in connection with Optical Mineralogy, the student is referred to: Groth's Physikalische Krystallographie, 3d edit.; Rosenbusch's Mikroskopische Physiographie, 3d edit.; Idding's Translation of Rosenbusch, 2d edit.; E. S. Dana's Text Book of Mineralogy, 14th edit.; and Atkinsons Ganot's Physics.

permits the crystal to transmit light) to be separated, so that they exist apart for a time; that is, think of the crystal as being composed of a "*body*" and a "*ghost.*"

Consider that a series of optical tests are made on these "ghosts," and the different ways in which they affect transmitted light ascertained. Then knowing the way these "ghosts" are united to their "bodies" will give a very clear idea as to how the crystals or "bodies" themselves affect transmitted light.

The "ghost" of a crystal of any system may be considered as a perfectly transparent sphere (it is not necessary in this connection to consider the "wave-surface") having all the optical properties of the crystal, the center of the sphere coinciding with the intersection of the crystallographic axes.

In some cases a *single image* of a point is seen through the "ghost" in all directions, and it has been proved that the light advances with equal velocity in all directions; that is, the "ghost" is symmetrical with respect to a point.

This is the case with the "ghosts" of *Isometric* crystals, and therefore it follows that these crystals* transmit light in like manner.

In isometric crystals any section, however cut, will transmit all the rays of light coming to it with no change other than that due to the law of simple or single refraction.† The same is true of *Amorphous* bodies, glass, etc., unless they have been subjected to strains or peculiar conditions during cooling.

All bodies in which the velocity of transmission of light is the same in all directions, and through which a single image of a point is seen in all directions, are called **Isotropic.**

It has been found that "ghosts" of some crystals have the property of showing a *double image* of a point, looked at through them in certain directions. Calcite, especially the variety Iceland spar, exhibits this phenomenon very beautifully.

This is called *double refraction*, and is due to an unequal elasticity of the "ether"‡ (which seems to be symmetrical either with respect to a line or to three planes at right angles to each other) causing the "ghosts" to transmit the doubly refracted rays of light

* It is interesting to remember in this connection that in the isometric system there is also the greatest possible symmetry of "form."

† Idding's Translation, p. 24.

‡ For this branch of optical physics see Idding's Translation, p. 34.

in such a manner that, for every direction of transmission, the rays always vibrate parallel to two planes at right angles to each other.* These planes are not always the planes of elasticity just mentioned, but are in most cases planes of intermediate elasticity.

Due to this inequality of elasticity, these two rays of light (polarized at right angles to each other) have different velocities, and, as the amount of refraction, or bending of a ray of light from its former course, is a function of the velocity of transmission, the emergent rays must have different directions and produce two separate images on the retina of the eye.

Of course it is only possible to make this test for double refraction, *i. e.*, the seeing of a double image, on crystals which have very strong double refraction like calcite. It is always convenient, however, to think of double refraction as producing this effect. In most cases, the separation of the two images is so slight as not to be perceived by the eye, and the practical method of testing a substance for double refraction will be given later, see p. 454.

All crystals in which the velocity of transmission of light is dependent on the direction, and which transmit rays of light, polarized in two planes at right angles to each other, *i. e.*, give a double image, are called **Anisotropic**, or crystals which have *double refraction.*

To this class belong all crystals except those of the *Isometric* system.

The crystals which show double refraction are further divided into two groups:

1°. *Uniaxial*, or those that have one direction parallel to which there is no double refraction, that is a single image only is seen through a section cut at right angles to this direction. To this group belong all *Tetragonal* and *Hexagonal* crystals.

2°. *Biaxial*, or those that have two directions parallel to which there is no double refraction, that is a single image only is seen through sections cut at right angles to these two directions. To this group belong all *Orthorhombic*, *Monoclinic* and *Triclinic* crystals.

The direction parallel to which there is no double refraction is called an **Optic Axis.**

* This can easily be proved by using a nicol and a plate of calcite which shows a double image. If the nicol is held between the calcite plate and the observer's eye, it can be so adjusted that only one image is seen. If now the nicol is revolved 90°, the first image will disappear and the other image alone will be seen.

The directions, at right angles to each other, parallel to which the rays of light vibrate in passing through a section of a doubly refracting substance may be called **Directions of Elasticity.**

In certain directions, always at right angles to each other, the effects of the "elastic ether" on the transmission of light are at a maximum, a mean or a minimum. These directions are called **Axes of Elasticity.**

It must always be borne in mind that optic axes and axes of elasticity are not lines but only directions.

In the case of *Uniaxial* crystals, the optic axes of the "ghosts" are parallel to the vertical axes c of the crystals, and the distribution of the "ether" is symmetrical with respect to c.

The *Uniaxial* crystals contain two axes of elasticity, one parallel to the vertical axis c and the other at right angles to this direction.

It will readily be seen that any section parallel to the base, being at right angles to an optic axis, acts like a section of an isotropic crystal, and will transmit all the rays of light coming to it with no change, other than that due to the law of simple or single refraction. Any section parallel to the vertical axis c, contains two axes of elasticity; and of the two rays of light, that which is vibrating parallel to the basal plane, is called the *ordinary ray O*, the other ray being called the *extraordinary ray E*.* The index of refraction of O is denoted by ω and that of E by ε. Any other section contains two directions of elasticity, always at right angles to each other; one direction being the trace of the plane, passing through the incident ray and the vertical axis c of the crystal, on the plane of the section; and the other direction being at right angles to this.

In the case of *Biaxial* crystals the relations of the "ghosts" and the crystals are not always so simple. The "ghosts" have been found to contain three axes of elasticity ($\mathfrak{a}$ = the maximum, $\mathfrak{b}$ = the mean, and $\mathfrak{c}$ = the minimum) at right angles to each other. These axes of elasticity are parallel to the intersections of the three planes, towards which the distribution of the elastic "ether" is symmetrical. The index of refraction of the ray vibrating parallel to $\mathfrak{a}$ is denoted by α, that of the ray vibrating parallel to $\mathfrak{b}$ by β, and that of the ray vibrating parallel to $\mathfrak{c}$ by γ.

When these "ghosts" are united to their crystal "bodies" it is found that:

* See Idding's Translation, p. 33.

In the *Orthorhombic* system the axes of elasticity are parallel to the crystallographic axes.

In the *Monoclinic* system one axis of elasticity is parallel to the ortho axis $\bar{b}$, the other two axes of elasticity are in the plane of symmetry* normal to the axis $\bar{b}$, but are not parallel to either the vertical axis c or the clino axis $\dot{a}$. The relative positions of these axes will be best understood by the accompanying figures. Fig. 1. represents a section parallel to the clinopinacoid, ∞ P $\breve{\infty}$ (010). The axes of elasticity are denoted by dotted lines, and the crystallographic axes by solid lines. The ortho axis $\bar{b}$ and the remaining axis of elasticity are normal to the pinacoid plane. In this case the symmetrical "ghost" is only attached, as it were, to the crystal along one line or direction. The angles $x\,o\,c$ and $c\,o\,y$ are called extinction angles, and vary with different species, being very characteristic of some minerals such as amphibole and pyroxene.

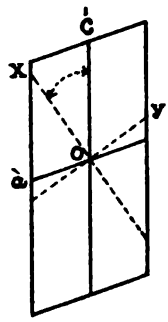

FIG. 1.

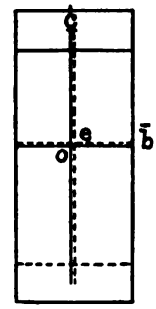

FIG. 2.

Consider now an orthopinacoid section, ∞ P $\bar{\infty}$ (100). In Fig. 2 $o\bar{b}$ is the ortho axis $\bar{b}$, $o\,c$ the vertical axis c, $e\bar{b}$ an axis of elasticity parallel to $\bar{b}$ and $e\,c$ a direction of elasticity parallel to c. The direction $e\,c$ is not an axis of elasticity, because the elasticity in that direction is intermediate in value between the two values of the axes of elasticity lying in the plane normal to $\bar{b}$. There is no extinction angle in an orthopinacoid section. The same is true of a basal section, and all sections in the ortho zone† 0 P: ∞ P $\bar{\infty}$ (001:

* Moses & Parsons, *Mineralogy, Crystallography and B. P. Analysis*, p. 37.

† A preliminary knowledge of crystallography and zones is here assumed. See Moses and Parsons, *Mineralogy, Crystallography and B. P. Analysis*, and E. S. Dana's *Text Book of Mineralogy*, p. 59.

100). We see that for sections in the prism zone $\infty P \breve{\infty} : \infty P \bar{\infty}$ (010 : 100), *i. e.*, parallel to the vertical axis, the extinction angles will vary from 0°, when the section is parallel to the orthopinacoid to a maximum value when the section is parallel to the clinopinacoid.

In the *Triclinic* system no axis of elasticity is parallel to any crystallographic axis. The symmetrical "ghost" has therefore no symmetrical connection with a Triclinic crystal "body," and in all possible sections there will be extinction angles.

In all *biaxial* crystals the two *optic axes* are inclined to each other, making what is called the *axial angle*, denoted by $2E$.* This angle is really the apparent angle measured in air, $2V$ being the true axial angle, but in many cases only $2E$ is recorded. The optic axes always lie in the plane of the axes of greatest and least elasticity, and the angles between them are always bisected by these axes of elasticity. The axis of elasticity bisecting the acute axial angle is called the *acute bisectrix*. An approximate idea of the value of the axial angle can be obtained by the use of the petrographical microscope, as described later, p. 467. The axial angle is often a convenient differentiation between such minerals as muscovite and biotite. The location of the optic axes in mineral species is not usually important, unless the uniaxial or biaxial nature, or the optical character is required. The determination of the axes or directions of elasticity and their relative values is, however, generally very important. The axial angle will vary with light of different wave length or color, and this variation is called *dispersion* of the optic axes. Dispersion of the axes of elasticity also takes place, but can be disregarded in ordinary investigations.

In closing, a very important fact to remember is, that any section of a crystal (not normal to an optic axis) will always transmit rays of light, vibrating parallel to two directions of elasticity at right angles to each other. These directions of elasticity may or may not be axes of elasticity. This of course would not be true of isometric crystals, which produce no double refraction.

* For methods of measuring the axial angle see E. S. Dana's *Text Book of Minerology*. p. 149.

PART II.

THE PETROGRAPHICAL MICROSCOPE. *

The *petrographical microscope* is essentially an ordinary microscope † with the following important additional equipment. It must be provided with: 1° a *polarizer* (a piece of apparatus for giving polarized light) placed below the stage; 2° an *analyzer* (a piece of apparatus for analyzing the rays of light after they have passed through the polarizer and transparent section) placed between the objective and the eye; 3° a *stage rotating* about an axis which is the line of sight of the microscope. A very convenient type of microscope is that made by Seibert of Wetzlar (No. 11 *a*), Fig. 3.

The *reflector a* is usually fitted with a plane mirror on one side, and a parabolic mirror on the other. The plane mirror should be used with sunlight, and the parabolic mirror with artificial light, in order to make the rays of light as nearly parallel as possible.

The *polarizer* is in most cases a nicol prism, set in a suitable frame *b*, and made as follows:

For the *nicol prism* "a cleavage rhombohedron of calcite (the variety Iceland spar is universally used in consequence of its transparency) is obtained, having four large and two small rhombohedral faces opposite each other. In place of the latter planes, two new surfaces are cut, making angles of 68° (instead of 71°) with the obtuse vertical edges; these then form the terminal faces of the prism. In addition to this, the prism is cut through in the direction HH′, Fig. 4, the parts then polished and cemented together again with Canada balsam. A ray of light, *ab*, entering the prism, is divided into two rays polarized at right angles to each other. One of these, *bc*, on meeting the layer of balsam (whose refractive index is less than that of the ray *bc*), suffers

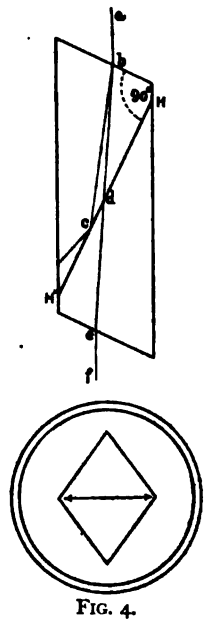

FIG. 4.

* For a short historical sketch of the use of the microscope in connection with Petrology, see G. H. William's pamphlet, *Modern Petrography* (*Monographs of Education*), Boston, 1886.

† For description of the ordinary microscope, eye-pieces, objectives, magnification, etc., see *Manipulation of the Microscope*, by Ed. Bausch.

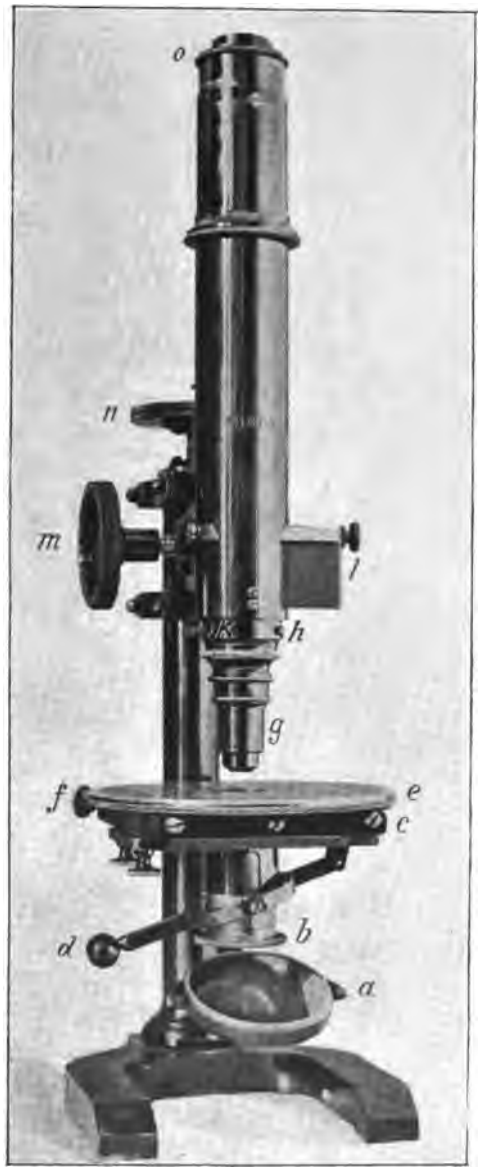

FIG. 3.

total reflection, and is deflected against the blackened sides of the prism and extinguished. The other, *bd*, passes through and emerges at *e*, a completely polarized ray of light, that is, a ray with vibrations in one direction only, and that the direction of the shorter diagonal of the prism." * The vertical plane through the shorter diagonal may be called the *plane* of *vibration*† of the nicol.

The polarizer must be below the stage *c*, and is generally adjusted so as to have its plane of vibration parallel to the N. and S. cross-wire in the eye-piece *o*. It is important to know the direction of the plane of vibration of the polarizer or lower nicol; as we can then determine, when absorption of light occurs in a mineral, the direction in this mineral parallel to which the absorbed rays are vibrating. The polarizer slides in an outer shell or frame, and, by means of a lever *d*, can easily be raised or lowered.

On the top of the nicol is placed the *condensing lens* for getting *convergent* light, and the adjustments are so arranged that when the nicol is up as far as it will go, the condensing lens ‡ is brought almost in contact with the lower surface of the transparent section resting on the stage.

The *rotating* circular *stage e* is supported on a suitable frame *c*, and arranged so that its axis of rotation coincides with the line of sight of the microscope. The stage is graduated, and, by means of an index fixed to the frame, the angular rotation can always be obtained. It is also provided with two adjusting screws§ *f* by means of which the axis of rotation can be accurately centered.

The method of centering is as follows: Bring some prominent mark in the section exactly in coincidence with the intersection of the cross-wires in the eye-piece. Rotate the stage 180°, and correct one-half the error by means of the centering screws, and the other half by moving the section on the stage. Check the result by rotating the stage 180° again, and if necessary make the corrections in the same way until the adjustment is satisfactory.

* Text Book of Mineralogy, by E. S. Dana, p. 133.

† It is convenient to assume that the vibrations of the polarized light are taking place in this plane, called the "plane of vibration," but all the phenomena caused by polarized light could be also explained on the assumption that the vibrations were taking place at right angles to this plane.

‡ This condensing lens must be removed when very low power objectives are used.

§ Some microscopes are provided with adjusting screws bearing on the frame holding the objective, which can then be accurately centered to the axis of rotation of the stage.

The *objective** *g* screws into the collar *h*, which has a slot *k*, in the upper portion, for the introduction of a sensitive color plate, a ¼ undulation mica plate or a quartz wedge.†

The slot *k*, is usually so arranged that, when the sensitive color plates are introduced, the axes of these plates will make an angle of 45° with the planes of vibration of the crossed nicols, and the interference color produced will thus be at its maximum intensity.

A revolving *nose-piece* is sometimes used which can be attached to the collar *h*, and which is arranged to carry two or three objectives, which can thus be very quickly brought into position for use. This is convenient in passing rapidly from observations with parallel light to observations with convergent light, which must be made with a high power objective. The difficulty is that recentering is generally required.

The *analyser*‡ or upper nicol is contained in the frame *l*, which is arranged so as to slide in and out of the tube of the microscope.

The plane of vibration of the analyser is generally fixed by the instrument maker so as to be parallel to the E. and W. cross-wire in the eye-piece. Consequently when the frame *l* is pushed into the tube, the analyser is introduced in the line of sight between the objective and the observer's eye, with its plane of vibration at right angles to the plane of vibration of the polarizer; that is the nicols are crossed. When the nicols are crossed, if they are properly adjusted, no light can pass through to the eye and the field of view should be dark.

The *eye-piece*§ *o*, fits into the top of the tube, and, by means of

* In the Seibert Microscope use objective No. 00 for the first general study of a rock section, No. II for general use and No. V for observations with convergent light. In the case of an English Microscope a 1″ to ¼″ objective is used for general purposes and a ¼″ to ⅛″ for observations with convergent light.

† See Iddings Translation, p. 63, for description of quartz plate; p. 65, for quartz wedge; and p. 81 for ¼ undulation mica plate.

‡ In some microscopes the analyser is in the form of a "cap" nicol, arranged to be fitted over the top of the eye-piece, and not introduced in the microscope tube as shown here. This form is not so convenient, as the "cap" nicol must be set by hand every time it is desired to make observations with crossed nicols. But at the same time it avoids any possible refocusing which may be necessary when the other type of analyser is introduced in the tube.

§ In the Seibert microscope eye-piece No. 0, is used for most purposes. Other eye-pieces, Nos. I and III, with cross-wires, are used for different degrees of magnification, and one eye-piece No. II, without cross-wires, is provided to be used in connection with an eye-piece micrometer. Eye-pieces with cross-wires and different degrees of magnification are also provided with the English microscopes.

a little projecting piece fitting into a slot in the frame, can always be adjusted so as to have its cross-wires parallel to the planes of vibration of the two nicols.

Some instruments are provided with an additional slot in the ube between the analyser and the eye-piece for the introduction of a Bertrand lens, which is used to magnify the interference figures produced by convergent light.

The first approximate focusing is made by the screw *m*, and the fine adjustment by the screw *n*.

In focusing always start with the objective very near the section, and move it away until the right focus is obtained. Never move down towards the section in obtaining the focus, as there is danger then of striking the objective against the section.

PART III.

Investigation of Microscopic And Optical Characters of Minerals.

Characters of Opaque Minerals, observed by *incident* light. Form, Lustre, Color, Cleavage, etc., recognized in the same way as in the case of macroscopic specimens. In order to make the observations by incident light alone, the beam of light from the reflector-mirror must be cut off by holding the hand over the mirror or by moving the mirror.

Characters of Transparent Minerals, observed by *transmitted* light. The petrographical microscope for these observations is supposed to be in the condition of an ordinary microscope, both nicols being out of the field and a strong beam of light coming up through the transparent section from the reflector below.

The characters are considered in the order in which they would most naturally appear to the observer during a complete investigation with the microscope.*

(a). **Form.**† *Complete Crystals*, with definite crystalline outline, *i. e.*, crystals that have formed when conditions were favorable for

* With the Seibert microscope, Fig. 3, the No. 0 eye-piece and the No. II. objective will prove most satisfactory for the following tests. With an English microscope use an ordinary eye-piece and a 1″ or ¾″ objective.

† Twins may be recognized just as in macroscopic specimens, and zonal structure noticed if the zones differ in color. When a colorless mineral is surrounded by other colorless minerals, of about the same index of refraction, its outline is often best brought out by observation between crossed nicols.

complete development. Such crystals are often called *Idiomorphic*, see Fig. 5. Crystals that are large in comparison with other accompanying crystals may be called *Phenochrysts*. In some cases,

FIG. 5.—Idiomorphic augite crystal in camptonite. The section is about at right angles to the vertical axis c, and shows the intersecting cleavages parallel to the prism of 87° 06′. Keene Valley, N. Y.

by a careful study of the outline of several sections of the same mineral, and by a measurement of the angles, it is possible to determine the common crystallographic form of the mineral. For measuring the angles have the stage accurately centered, then bring

FIG. 6.—Allotriomorphic quartz q, showing "low relief," plagioclase p and decomposed feldspar o in granite. As seen with crosed nicols.

the vertex of the angle to be measured to the intersection of the cross-wires in the eye-piece. Bring one of the sides in coincidence with one of the cross-wires. Note the reading of the graduated circle and rotate the section until the other side is in coincidence with the same wire. Take the reading again and the difference will be the angle required.

Incomplete Crystals, without definite crystalline outline, whose bounding surfaces are more or less determined by those of adjacent crystals. Such crystals are frequently called *Allotriomorphic*,* see Fig. 6. This allotriomorphic form must not be confounded with the worn or rounded boundaries of the component grains in clastic rocks.

Corroded Crystals,† whose fretted outline is undoubtedly due to corrosive action of the magma before solidification, see Fig. 7.

FIG. 7.—Corroded sanidine crystal in perlite.

Broken or Strained Crystals. In some cases what were formerly larger individuals have been broken or shattered by dynamic action to much smaller fragments, see Fig. 8, showing crushed rim of fragments surrounding feldspar "auge." In other cases an actual bending or distortion of the crystal has taken place, and again sometimes the effect of mechanical stress is only shown by the so called "wavy" extinction. See p. 458 and Fig. 8, showing

* The term "Anhedron," meaning without planes, has been suggested by L. V. Pirsson to describe in rocks the crystal fragments which have no plane faces, as, for example, the augites of augitic rocks, *Science*, Jan. 10, 1896, p. 49.

† Partial resorption and recrystallization may produce a border of secondary minerals, surrounding the original crystal.

FIG. 8.—Orthoclase "auge" (Carlsbach twin), showing bending and "wavy" extinction, surrounded by crushed rim of mineral fragments. As seen with crossed nicols. "Augen" gneiss, Bedford, N. Y.—B. 13.

a carlsbad twin of feldspar that has been bent and at the same time shows marked "wavy" extinction.

Crystallites, in general those incipient forms of crystals, which have not yet reached a stage of development sufficient to show double refraction, see Fig. 9, *a*. Quite a number of names are used to describe the different forms that occur.

FIG. 9.—Crystallites and Microlites *a*. Skeleton Crystals *b*.

Microlites, more or less completely defined microscopic crystals, which usually show double refraction, but cannot be always specifically determined, see Fig. 9, *a*.

Skeleton Crystals or crystallizations which have not produced entire and complete individuals, see Fig. 9, *b*.

(b). **Color.** It must be remembered that the colors observed are always due to transmitted light and may be called "*absorption tints*." Minerals which in hand specimens are opaque, are often colored in sections; and minerals which are commonly colored may appear colorless in sections. At times color may be given to a section simply by the presence of a great number of inclusions.

(c). **Relief.** The appearance of the surface and outline of a mineral, dependent on the strength of its refractive index,

$$n = \frac{\sin i}{\sin r}.$$

High numbers indicate strong refraction and *vice versa*. In the case of uniaxial and biaxial minerals the mean value of the indices of refraction is used.

FIG. 10.—Olivine crystal in basalt showing "high relief" and cleavage.

A mineral which has *weak refraction* appears to have what is called *low relief*, *i. e.*, no dark contours and a smooth surface, see Fig. 6.

A mineral which has *strong refraction* appears to have *high relief*, *i. e.*, distinct dark contours and a rough or "shagreened" surface,*

* The surfaces of all minerals in sections are more or less rough, but this roughness is only made visible when there is a marked difference between the indices of refraction of the minerals, and the index of refraction of the balsam in which the minerals are embedded. The index of refraction of balsam is about 1.5, so it is only when the mineral has a high index of refraction that its surface appears rough. When internal structure is to be studied, the crystal should be surrounded by a fluid of nearly the same index of refraction as that of the crystal, and when the exterior of the crystal is to be studied then a fluid should be used with a very different index of refraction.

which has bright illumination and appears to stand out above the surfaces of the surrounding minerals with weaker refraction, see Fig. 10.

The practical way of testing for the *relief* of a mineral is to make use of the lens for convergent light, which is placed on top of the lower nicol immediately below the section.

By lowering* the lens the high relief of a mineral section is made very apparent.

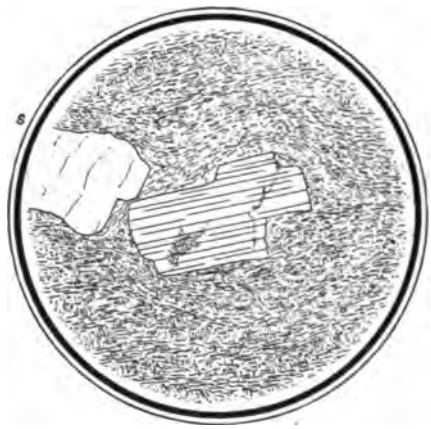

FIG. 11.—Biotite, showing perfect cleavage and "low relief," in rhyolite. A fragment of a sanidine crystal is seen at *s*.

(d). **Cleavage,** which appears as more or less distinct and regular lines or cracks, see Figs. 11 and 12.

These cleavage cracks may be parallel or intersect, depending on the position of the section relative to the cleavage planes of the crystal.

Cleavage is sometimes best observed by slightly lowering the condensing lens under the section. Crystals that have two good cleavages often develop so that the direction of elongation is par-

* The Seibert microscope has a very convenient and quick lowering adjustment, by means of the lever *d*, for making this test rapidly. For convenience the lower nicol and condensing lens are generally left in place below the stage of the microscope, as polarized light serves as well for these investigations as ordinary light. An additional advantage in this arrangement is that the condensing lens is always ready for the "relief" test and the lower nicol for the pleochroism test; but it must be remembered that the polarizer or lower nicol cuts out one-half of the light, which comes to it from the reflector, and this loss is important when high power objectives are to be used. When very low power objectives are used the condensing lens must be removed.

allel to the intersection of the two cleavages, while in the case of crystals with one good cleavage the tendency seems to be towards a tabular habit parallel to the cleavage. When sections show in-

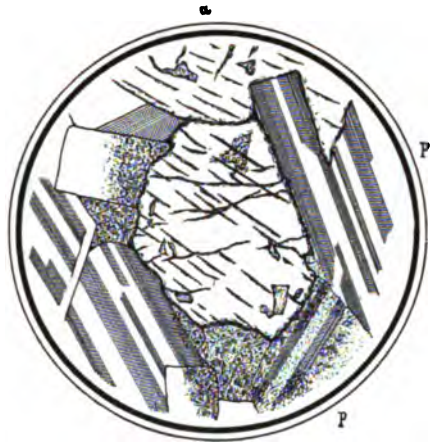

FIG. 12.—Augite *a*, showing good cleavage, and plagioclase *p* in diabase. The plagioclase shows "polysynthetic" twinning between crossed nicols.

tersecting cleavage cracks it is often possible to easily recognize the mineral by its known cleavage angle, as in the case of amphibole and pyroxene.

(e). **Fracture**, which appears as irregular and non-parallel cracks, see Fig. 13.

FIG. 13.—Garnet in mica schist, showing fracture and "high relief." Franconia, N. Y.

(f). **Inclusions,** which may be *solid* (either distinct crystals or glass), *fluid* or *gas,* see Fig. 14. These inclusions are differentiated

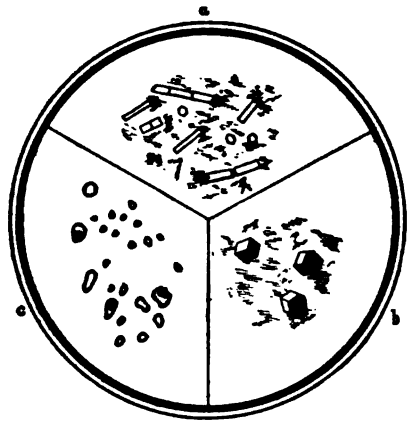

FIG. 14.—Apatite in feldspar *a*. Garnets in quartz, Branchville, Ct. *b*. Liquid inclusions of CO_2, some showing gas bubbles, in quartz *c*.

by the fact that the solid inclusions generally have sharp contours, the fluid inclusions distinct dark borders, and the gas inclusions broad dark borders more distinctly marked than those of the fluid inclusions. The fluid inclusions often contain a bubble of gas. The inclusions may have a definite or indefinite position in the crystal in which they occur, and can sometimes be more distinctly seen by using convergent light or a "spot" lens.

(g). **Schiller Structure.** "Is that in which cavities of definite form and orientation ('negative crystals') are developed along certain planes and filled or partially filled by material dissolved out of the enclosing crystal,"* see Fig. 15.

Characters Observed by Polarized or Parallel Transmitted Light.

The polarized light is obtained by passing the beam of light from the reflector through the polarizer or lower nicol,† which must be in place below the stage of the microscope.

* Harker's *Petrology for Students*, p. 280.

† The lower nicol is generally so adjusted that its plane of vibration is parallel to the north and south cross-wire in the eye-piece. This adjustment can be tested by means of a section of biotite, showing cleavage cracks. When the plane of vibration of the polarizer is parallel to the N. and S. cross-wire in the eye-piece, the biotite section becomes almost dark when its cleavage cracks are parallel to the same cross-wire. The upper nicol, or analyzer, must, of course, be removed during this test. This method is more convenient than taking the nicol out of its frame, in order to ascertain the plane of vibration (the direction of its shorter diagonal).

(a). **Pleochroism,** that property which all anisotropic minerals have, to a greater or less extent, of absorbing certain colored rays in certain directions, thereby showing different colors in different directions by transmitted light. Uniaxial minerals are dichroic showing two differences in color, produced by the rays which vibrate parallel to the direction of the vertical axis *c* and the plane of the basal axes. Biaxial crystals are trichroic showing theoretically three differences of color, corresponding very nearly to the directions of the three axes of elasticity. Any given section of a biaxial crystal will, of course, appear only dichroic.

FIG. 15.—Hypersthene showing "Schiller" structure.

The practical way of testing for *pleochroism* is as follows: Revolve the stage, carrying the section, when a change in the color of the mineral will be noticed, if it is pleochroic. This pleochroism may appear as an actual change in color or simply as a change in the shade of the same color. In some cases it may be so weak as hardly to be noticed, when it is best to make the test with the condensing lens in position immediately under the section, or by rotating the lower nicol instead of revolving the stage. The color of the light, vibrating parallel to certain definite crystallographic directions in minerals, is often very characteristic.

Pleochroism may often be noticed with ordinary light in the case of hand specimens.

(b). **Absorption,** that property which some minerals have of absorbing all or nearly all of the light in certain directions. The change is one of intensity of light rather than of color, and is

tested for in the same way as for pleochroism. If the absorption is strong, the crystal changes from its usual color to almost a black, and the interference colors may be masked. Strong absorption is characteristic of certain minerals, such as biotite, amphibole and tourmaline, and takes place parallel to definite directions in these minerals.

Characters Observed with both Polarizer and Analyzer* in Position, that is with "Crossed Nicols."

When the nicols are accurately crossed, the field should be quite dark, and if this is not the case the adjustments must be looked to. The condensing lens should be removed for these tests as they are to be made with parallel light, but as a matter of convenience instead of removing the condensing lens, the polarizer with the lens on top may be lowered, when the results will be about the same as with parallel light.

Isotropic Character. Sections of isotropic crystals are perfectly dark and remain so during a complete rotation of the stage through 360°. The explanation is very simple. Light being transmitted by an isotropic crystal in all directions without double refraction; it follows that the light from the polarizer, after having passed through the section, comes to the analyzer still vibrating in the plane of vibration of the polarizer. Hence it is entirely cut out by the analyzer.

Amphorous transparent substances act in the same way and remain dark during complete rotation of the stage.

Optical anomalies, i. e., apparent double refraction, may occur in isometric crystals and in amorphous substances that have been subjected to strains.

Anisotropic Character. If a section of an anisotropic crystal were very thick and the double refraction very strong, as in calcite, a double image of a point would be seen through it with both the polarizer and analyzer out of the field. The only exception being when the line of sight was parallel to an optic axis. But as most crystals have not such strong double refraction, and as the sections studied are very thin, the following method is used to determine this *anisotropic* character or *double refraction.*

* In the Seibert microscope the analyzer or upper nicol is so fitted that it slides in and out of the tube of the microscope with its plane of vibration always at right angles to the plane of vibration of the polarizer or lower nicol.

In Fig. 16, let P P′ be the plane of vibration of the polarizer, and A′ A the plane of vibration of the analyzer. All the light, after it has passed through the polarizer, is vibrating parallel to P P′ when it reaches the lower side of the transparent crystal, *c d e f*, on the stage of the microscope. In this transparent section let *o b* and *o a* be the two *directions* of *elasticity*, *i. e.*, the only two directions parallel to which the rays of light can vibrate in passing through the section.

Let *o m* represent the amplitude of vibration of a ray from the polarizer. When this ray reaches the section it cannot get through

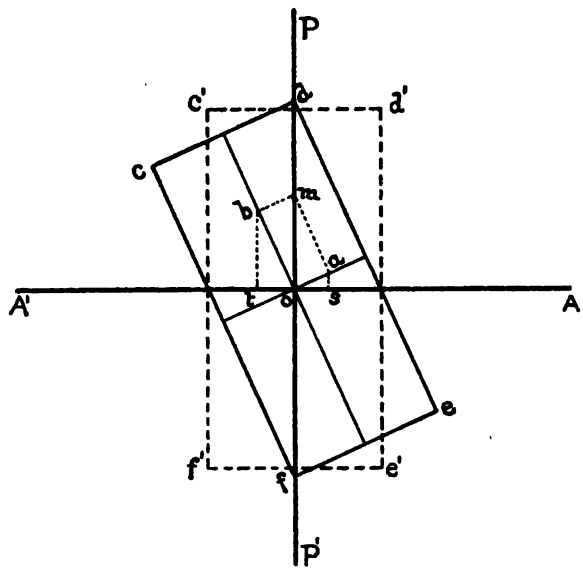

FIG. 16.

it vibrating in the direction *o m*, but a portion of it can get through vibrating in the direction *o b* and a portion vibrating in the direction *o a*. From *m* draw perpendiculars to *o b* and *o a*. Then according to the law of the parallelogram of forces *o b* will represent the amplitude of vibration of the part of the ray passing through the crystal vibrating in the direction *o b*, and *o a* will represent the amplitude of vibration of the part of the ray passing through the crystal vibrating in the direction *o a*. We have thus two rays passing through the crystal, polarized at right angles to each other.

When these two rays come to the analyzer, whose plane of vibration is A′ A, they cannot get through vibrating in their present directions, but components of their rays, *o t* and *o s*, can get through vibrating parallel to the plane A′ A.

As the elasticities in the crystal are not equal in the directions *o b* and *o a*, the two polarized rays pass through with different velocities and on emergence one ray is slightly ahead of the other. This is still true of the components of these two rays that pass through the analyzer, vibrating parallel to its plane of vibration A′ A.

Hence we have two series of rays coming to the eye, polarized in the same plane, but one set slightly in advance of the other. These two series of rays, having their vibrations in the same plane and being in different "phase," will interfere and produce some *interference* or *polarization* color. The interference color is independent of the proper color or "absorption tint" of the crystal section.

Now suppose the stage to be rotated until the section *c d e f* takes the position *c′ d′ e′ f′*. The section will now be found to be dark and no interference color will be seen. This is due to the fact that the directions of elasticity in the section are parallel to the planes of vibration of the crossed nicols, consequently the light passes through the section still vibrating parallel to the plane P P′ of the polarizer and is all cut out by the analyzer. Darkness will occur every 90° and therefore four times during a complete rotation of the stage. The interference color is also observed to vary in intensity, but not in color, and to be at its maximum 45° from the positions of darkness.

Sections of uniaxial crystals at right angles to the optic axis (which is a direction parallel to which no double refraction takes place) act like isotropic substances and remain dark during a complete rotation of the stage. In the biaxial crystals, a section at right angles to an optic axis generally show more or less illumination, but this illumination does not change as the stage is rotated.*

The only way to find out whether these sections are truly isotropic, or simply at right angles to an optic axis, is to test them with convergent light as described later, see p. 463.

Double Refraction, whose strength can be estimated by observing the *interference* or *polarization* colors.

* Idding's Translation, p. 37, and p. 61.

The *interference colors* of minerals with very weak double refraction vary from a bluish gray to a grayish white. As the strength of the double refraction increases the colors become the very intense bright tints of the spectrum, yellow, red, blue, green, etc., called the first and second order colors. As the strength of the double refraction still increases the colors pass through the tints of the spectrum in sequence (called orders), becoming paler until finally, when the double refraction is very strong, the colors become the neutral, almost colorless tints of the higher orders. The eye must be trained to appreciate the colors of different orders, and the student is advised to practice with mineral sections, of known strength of double refraction, and compare the resulting interference colors with a color chart.*

The interference color really depends on the thickness of the crystal section, the relative values of the axes of elasticity, *i. e.*, the strength of the double refraction, and the position of the section in the crystal. This latter condition may be the cause at times of unusual variation in the interference color. As rock sections are generally of about the same thickness † the characteristic interference colors of minerals do not usually show very much variation.

Extinction and Extinction Angles. When the section, see Fig. 16, is in such a position that its directions of elasticity are parallel to the planes of vibration of the nicols, no light can pass through the analyzer, and the section is dark. Hence the light is extinguished and this phenomenon is called *extinction.*

Extinction is said to be *parallel* or *symmetrical* when the directions or axes of elasticity are parallel to any crystallographic lines or directions, or bisect the angles between these lines. The crystallographic lines or directions may be either cleavages or the boundaries of idiomorphic crystals.

* A chart of interference colors can be obtained from Baudry et Cie, Paris, and is also published in *Les Mineraux des Roches*, by Levy and Lacroix, and in Rosenbusch's *Mikroskopische Physiographie.*

† It must be remembered that very carefully prepared sections, especially those made abroad, are usually thinner than those made more carelessly or by amateurs. Therefore the interference colors, obtained from all such minerals, will be lower in order than those which would be given by thicker sections of the minerals. A notable example would be that the feldspars, quartz and the orthorhombic pyroxenes would generally give only the grays, instead of any of the bright 1° order colors. It is well in this case to pick out some well known mineral in the section, as quartz, and note its interference color. Knowing how this varies from the normal interference color, due allowance can be made for the colors given by the other minerals.

This kind of extinction is shown by all sections of anisotropic crystals, except those in the monoclinic and triclinic systems.

In the monoclinic system sections in the ortho zone 0 P : ∞ P$\bar{\infty}$ (001 : 100) also show it.

When the *extinction* is not symmetrical it is called *oblique*, and is shown by all sections of monoclinic crystals [except those in the ortho zone 0 P : ∞ P$\bar{\infty}$ (001 : 100)] and triclinic crystals.

Extinction which does not take place over the whole of the section of a simple crystal at the same moment, but passes over the section like a dark wave or shadow is said to be "*wavy*;" and indicates that the crystal has been subjected to mechanical forces producing a change in the position of the axes of elasticity in different parts of the crystal, see Fig. 8.

The angle between a direction or axis of elasticity in the section, and some known crystallographic direction (as a cleavage or crystal outline) is called an *extinction angle*, and is measured in the following way: Find the positions of the directions or axes of elasticity in the section, which must be parallel to the cross-wires when extinction takes place. Note the reading on the graduated circle of the stage. Now remove the upper nicol, in order to get a more distinct view of the field, and rotate the stage until you bring some known crystallographic line into parallel position with the cross-wire selected as a reference line. Take the reading of the graduated circle again, and the difference between these two readings will be the *extinction angle*.

It can readily be seen that depending on which way the section is rotated, either a small or a large extinction angle will be obtained, the two angles being complements of each other. The extinction angle generally recorded is that between the nearest axis of elasticity and the vertical axis c.

In monoclinic minerals the maximum value of the extinction angle (the only angle of real value in differentiating the mineral) can only be obtained from a section parallel to the clinopinacoid ∞ P$\bar{\infty}$ (010); but in practice sufficiently accurate results can generally be obtained by measuring the extinction angles of all sections of the same mineral, which seem to be about parallel to the vertical axis c, and then taking the maximum value obtained. Amphibole and pyroxene can easily be distinguished in this way.

Extinction is generally tested for by revolving the stage, carrying the section, until darkness is observed; the most accurate re-

sults being obtained by using monochromatic light. There are other more exact methods,* called Stauroscopic methods, for locating these directions or axes of elasticity. A quartz or gypsum test-plate, so prepared as to give some definite interference color, as red of the 1° order, may be introduced between the two nicols, and the section revolved until this color is exactly matched. This exact matching of color is only possible when the directions or axes of elasticity of the section are exactly parallel to the planes of vibration of the nicols, as otherwise some interference color would be produced by the section and the true color of the test-plate would not appear.

This method of testing can be employed to recognize the very weak double refraction of some minerals, whose interference colors are such dark or neutral grays as not to be noticed without this test. After the test-plate has been introduced, some slight variation in the color will be observed when the stage carrying the doubly refracting section is rotated.

Method of Testing for the Relative Value of the Two Directions or Axes of Elasticity in a Mineral Section.†

A mica, quartz or gypsum plate can be used to make this test. The directions of the maximum and minimum axes of elasticity must be known and marked on the plate.‡

The crystal section to be tested is placed on the rotating stage, between crossed nicols, and the directions or axes of elasticity determined by finding the directions of extinction. The section is now turned 45°, when the interference color will be at its maximum, and the directions or axes of elasticity will make angles of 45° with the planes of vibration of the nicols and the cross-wires in the eye-piece.

Now introduce § the test-plate, between the section and the an-

* Idding's Translation, p. 63.

† For a more elaborate discussion of this method, see Idding's Translation, p 64.

‡ In the case of the ¼ undulation mica plate these axes are easily found, as the minimum axis of elasticity *c* lies in the plane of the optic axes, *i. e.*, it is the line joining the loci of the the two black hyperbolas. The direction at right angles to this axis *c* is an axis of greater elasticity. In the case of the gypsum and quartz plates, these axes must be carefully determined by an expert.

§ The test-plates are generally introduced in the slot *k*, in a microscope of the Seibert type, or if a cap-nicol is used in a slot below this. In case no provision is made by the instrument maker for these test-plates, the regular analyzer is left out of

alyzer, so that its known axes of elasticity also make angles of 45° with the cross-wires in the eye-piece, bearing in mind at the same time the positions of its maximum and minimum axes of elasticity.

When the test-plate is introduced a new interference color will be noticed which is either higher or lower in the color scale * than the original interference color of the mineral section. When the known axes of elasticity of the test-plate are superposed over corresponding directions or axes of elasticity in the mineral section,

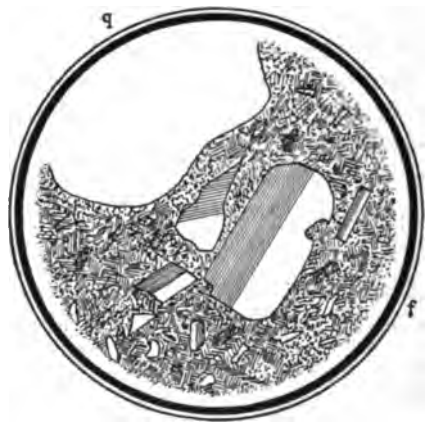

FIG. 17.—Sanidine crystal *f*, showing Carlsbad twin, and quartz *q* in rhyolite. Crossed nicols.

the effect is to thicken the section and the interference color rises in the scale.

When the axes of the test-plate are superposed over directions or axes of elasticity in the mineral section, which are not corresponding, the effect is to thin the section and the interference color sinks in the scale.

Hence by observation of the interference colors it is possible to determine the relative values of the directions or axes of elasticity in the mineral section. Great care should be taken when the test-

the tube, and a simple nicol prism is used as an analyzer and is held by the observer over the eye-piece. Care must be taken to have the plane of vibration of this nicol at right angles to that of the polarizer, and to leave sufficient room for the introduction, by hand, of the test-piece between the eye-piece and the nicol. With care the plates can be introduced with sufficient accuracy to make the test practical.

* A scale or chart of interference colors should be before the observer in order to avoid any mistakes as to whether the new color is higher or lower in the scale.

plate gives a higher interference color than the mineral section to be tested. When this is the case the effect of the mineral section on the interference color of the test-plate must be considered.

For minerals which have very strong double refraction, as zircons, so that the interference colors are of the high orders, it is advisable to use the method of testing with a quartz wedge.*

Structure.

(a) *Twinning*, generally noticed by the parts of the twin not extinguishing at the same time. It may also be observed, without crossed nicols, just as in the case of macroscopic minerals.

Twinning may be classed as: *simple*, Fig. 17; *polysynthetic*, due to repeated twinning after the same law, Fig. 12; and *crossed or "gridiron,"* due to repeated twinning after two laws, Fig. 18.

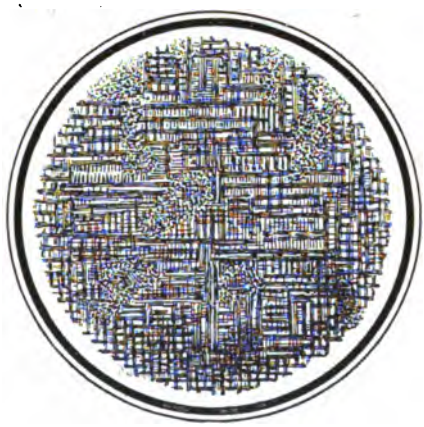

FIG. 18.—Microline, showing crossed or "gridiron" twinning. Crossed nicols.

(b) *Zonal* structure, often only made visible by the zones extinguishing at different times. It may, however, be noticed by the zones being of slightly different color, or by the zonal distribution of inclusions. In the case of the feldspars the zonal structure may be caused either by the crystal being formed of zones of different chemical composition, or by ultra-microscopic twinning,† Fig. 19.

(c) *Aggregate* structure, being a confused mass of separate little crystals, scales or grains all extinguishing at different times, Fig. 20.

(d) *Sphærulitic* structure, produced by the aggregation, in a

* See Idding's Translation, p. 65.

† Harker's *Petrology for Students*, 1895, p. 14.

radiate form, of crystals or crystallites. It is generally easily perceived by the dark cross, resulting from the extinguishing of the

FIG. 19.—Zonal feldspar crystal (Carlsbad twin) in trachyte. Crossed nicols.

light in those crystals whose axes of elasticity are parallel to the planes of vibration of the nicols. When the stage is revolved the arms of the cross do not rotate, Fig. 20.

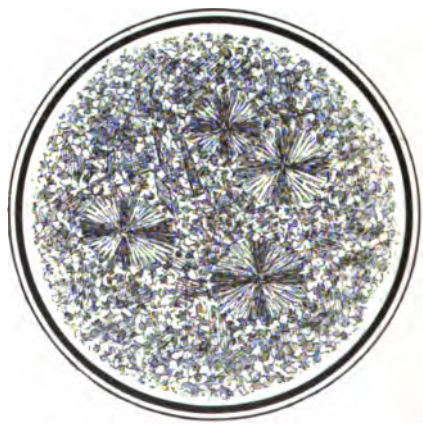

FIG. 20.—Sphærulites in felsite. Ground-mass shows aggregrate structure. Crossed nicols.

(e) *Pseudomorphic* structure, which may be partial or complete, and is noticed by the changed portions producing different optical effects from those of the original mineral. Sometimes, although

the pseudomorphism has been quite complete, the form of the original mineral or crystal may still be seen, Fig. 21.

FIG. 21.—Olivine decomposed to serpentine. The pseudomorphism has been quite complete, only small portions of the original olivine remaining. The outline of the parent crystal can be quite distinctly seen. Crossed nicols.

Characters Observed by Convergent Light.

Convergent light is obtained by passing the rays of polarized light through a strong condensing lens, which generally fits like a cap over the top of the polarizer. By means of a suitable adjustment the condensing lens can be brought very close to the lower surface of the section on the stage.

The lens thus sends a cone of light through the section, and used in connection with *crossed nicols* a series of optical phenomena, called *interference figures*,* are produced. A very high power objective † must be used, and when the eye piece is removed, a small image of the interference figure will be seen.

In some microscopes an arrangement is made for getting a magnified image of the interference figure, by retaining the eyepiece and using an additional Bertrand lens.

In order to get good results care must be taken to have strong illumination and the condensing lens close up under the section. The tests are best made with monochromatic light, but with white light the effects are substantially the same, the only difference

* Idding's Translation, p. 68.

† In the Seibert microscope use No. V objective, in English microscopes a ¼″ or ⅛″ objective.

being that the rings and curves are variously colored instead of being simply light and dark.

Isotropic substances show no *interference figures.*

Uniaxial Interference Figures.

(a) Sections normal to the optic or vertical axis c show a dark cross, with or without colored rings, Figs. 22 and 23.

FIG. 22.

FIG. 23.

The arms of the cross are parallel to the planes of vibration of the nicols, and the figure does not move when the stage carrying the section is rotated.

(b) Sections oblique to the optic axis show a portion of a dark cross, with or without colored rings, Fig. 24.

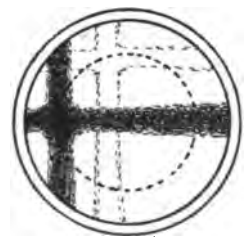

FIG. 24.

The centre of the cross is not in the axis of rotation, and as the stage bearing the section is revolved, the centre of the cross describes a circle, the arms always maintaining parallel positions.

If the section is still more oblique to the optic axis the centre of the interference cross may be outside the field of view, and only the dark arms will be seen swinging pass, when the section is rotated, thus making the figure rather indefinite.

Sections which are thick and have strong double refraction will show the cross and rings clearly and sharply defined, there being quite a number of rings crowded close together. Sections which

are very thin and have weak double refraction show only a broad dark cross and no rings. The interference figures will vary between these extremes, depending on the thickness of the section and the strength of the double refraction.

To obtain the most characteristic figures, observations must be made on sections about normal to the optic axis, that is sections which remain dark or nearly dark during complete rotation between crossed nicols in parallel light.

Optical Character, Positive or Negative. After having obtained a uniaxial interference figure, test it by means of a ¼ undulation mica plate. This plate must be introduced between the objective * and the analyzer in such a way that its axis of elasticity ¢, marked on the plate, makes an angle of 45° with the planes of vibration of the nicols.

When this is done the interference figure changes, or may more or less disappear, two dark spots or blotches being brought prominently into view. If rings are still seen it will be noticed that they have expanded in the quadrants occupied by the dark spots. This fact may make it possible to determine the optical character of a section, which is so oblique to the optic axis that the dark spots are not seen after the introduction of the mica plate.

If the optical character is *positive* the line joining these dark spots is perpendicular to the axis of the mica plate, see Fig. 25.

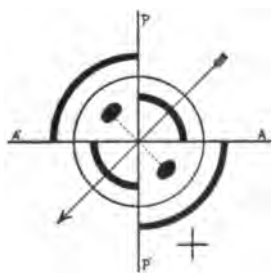

FIG. 25.

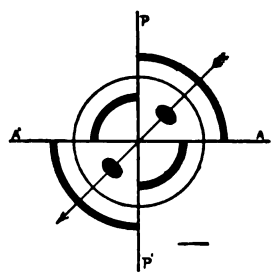

FIG. 26

If *negative* the line joining the dark spots coincides with the direction of the axis of the mica plate, see Fig. 26.

The (+) and (—) character is easily determined by remembering that the line, joining the dark spots, makes the + and — sign

* In the Seibert microscope there is a little slot *k* for this purpose just above the objective.

respectively with the axis of the mica plate. The axis of the mica plate (represented in the figures by an arrow) is of course not seen, but its position must be borne in mind when making this test.

If the mica plate does not give satisfactory results, which will be the case when the broad cross of a weak doubly refracting crystal is to be tested, use a quartz or selenite plate, cut the proper thickness to give the red color of the first order.

This plate must be introduced with its relatively greater axis of elasticity (previously determined and selected as a matter of convenience) making an angle of 45° with the planes of vibration of the nicols. Instead of the dark spots being seen there will appear two blue and two red quadrants. The diagonally opposite quadrants being of the same color.

In determining the (+) and (—) character consider the blue quadrants as the equivalent of the dark spots in the preceding case.*

Biaxial Interference Figures.

(a) Sections normal to an optic axis exhibit the interference figure shown in Fig. 27. As the stage, carrying the section, is ro-

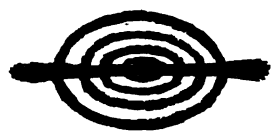

FIG. 27.

tated the bar changes into a hyperbola and back again into a bar.

As previously stated sections of biaxial crystals, normal to an optic axis, do not remain perfectly dark during rotation of the stage between crossed nicols in parallel light. On the contrary these sections of biaxial crystals remain uniformly illuminated.†

(b) Sections normal to the acute bisectrix (see p. 441), exhibit interference figures like those shown in Figs. 28 and 29.

FIG. 28.

FIG. 29.

* The optical character may be determined in parallel light by proving $c' = c$ (+) $c' = a$ (—).

† Idding's Translation, pp. 37 and 119.

Fig. 28 shows the appearance of the interference figure when the plane of the optic axes is parallel to the plane of vibration of either nicol, and Fig. 29 shows the appearance when this plane is inclined 45° to the planes of vibration of the nicols.

As the stage, carrying the section, is rotated the dark cross changes into two hyperbolas, which again unite to form a cross.

The centres of the small ellipses and the black hyperbolas mark the loci of the optic axes, and therefore indicate approximately the size of the *axial angle*, 2 *E*.

Sections in other positions, relative to the optic axes, give interference figures less definite in appearance than those just described; and the same conditions affect the appearance of the interference figures as in the case of uniaxial crystals. Very thin sections, of weak double refraction, may only show indistinct dark crosses or hyperbolas without any ellipses.

The section normal to the acute bisectrix, which will give the most characteristic interference figure, cannot be recognized except by an examination in convergent light. Therefore no clue can be obtained as to the best section to test, and the safest method is to test all the sections of the mineral occurring in the rock section.

It must be remembered that this uncertainity, in the choice of sections for testing, does not exist in uniaxial crystals; where the best sections are indicated by the fact that they remain dark or nearly so during complete rotation between crossed nicols.

Optical Character, Positive or Negative. When the axial angle is very small, so that the interference figure approaches that of a uniaxial crystal, the methods used for testing uniaxial figures are employed.

When, however, the axial angle is large, the following method can be used:

After having obtained an interference figure, from a section as nearly at right angles to the acute bisectrix as possible, the stage is rotated until the plane of the optic axes (the trace of which on the plane of the section is the line joining the loci of the two optic axes) makes an angle of 45° with the planes of vibration of the crossed nicols or the cross-wires in the eye-piece.

A quartz wedge * is now pushed in between the mineral section

* For construction of quartz wedge and a more detailed description of the method of determining optical character, see Idding's Translation, p. 65.

and the analyzer,* so that its axis $c' = c$ (previously determined and marked on the wedge) is either at right angles or parallel to the plane of the optic axes of the mineral section.

The optical character of the mineral is *positive* when the ellipses, surrounding the loci of the two optic axes, appear to expand or open out when the quartz wedge is pushed in with its axis parallel to the plane of the optic axes.

The optical character is *negative* when the ellipses appear to expand or open out when the wedge is pushed in with its axis at right angles to the plane of the optic axes.

As the ellipses expand they move from the loci of the optic axes towards the centre of the interference figure, and finally open into lemniscates which move outward from the plane of the optic axes.

Even when the section is very thin and the double refraction very weak, only the black hyperbolas without ellipses being seen, the test can be made; and colored ellipses will appear, after the pushing in of the quartz wedge, which will act in the same way as the normal ellipses of the interference figure.

Resumé of the Uses of Parallel and Convergent Light.

Parallel light is used to distinguish between isotropic and anisotropic substances, to locate directions and axes of elasticity, and to measure extinction angles and the relative values of the axes of elasticity.

Convergent light is used to distinguish between uniaxial and biaxial crystals, to determine whether a section that appears to be isotropic is really so or only normal to an optic axis, and to determine the optical character and dispersion.

Brief Scheme of Classification into Systems by Means of Optical Determinations.

HOMOGENEOUS.	The whole substance shows the same optical character, except in the case of twin crystals when the different portions of the twin are affected differently.
ISOTROPIC	All sections of the substance remain dark during a complete rotation between crossed nicols, and no interference figure is produced by convergent light.
Amorphous . .	Absence of crystalline form or cleavage.
Isometric . .	Presence of crystalline form or cleavage.

*The wedge can be introduced in either of the several ways described for the introduction of the test-plates on p. 459.

ANISOTROPIC . . .	Sections generally show some interference color and extinguish four times, at 90° apart, during complete rotation.
Uniaxial	Determined by character of the interference figures obtained by convergent light from sections which remain dark or nearly so during complete rotation.
	All sections show symmetrical extinction.
Tetragonal . .	Sections giving interference figures are four or eight sided, or show rectangular cleavage.
Hexagonal . .	Sections giving interference figures are three, six or nine sided, or show cleavage lines intersecting at 60°.
Biaxial	Determined by character of interference figures obtained by convergent light.
Orthorhombic .	Symmetrical extinction in all sections.
Monoclinic . .	Symmetrical extinction only in the ortho zone 0 P : ∞P$\bar{\infty}$ (001 : 100), all other sections show extinction angles.
Triclinic . . .	Extinction angles in all sections, although in some minerals these extinction angles may be very small.
AGGREGATE . .	Not homogeneous, but made up of an aggregation of individuals, all extinguishing at different times.

NOTE ON SUGAR ANALYSIS.

By P. A. LEVENE, M. D.

Up to the present no better method for quantitative sugar analysis has been found than the determination of the amount of copper reduced by the sugar. The most rational method is to collect the Cu_2O on a filter and weigh it. But as Cu_2O is very unstable it was proposed to weigh it as CuO or metallic Cu. The last method advanced by Soxhlet and Allihn acquired the largest application, and is even at present considered the most correct. But at different times various sources of error have been discovered in that method.

It was proved that the alkaline Fehling's solution attacked the asbestos of the filter and, therefore, renders the weight of Cu incorrect. (Formanek, Listy cukovaricke, after Zeitsch. f. Anal. Chem. xxx-64.)

Others showed experimentally that the asbestos lost in weight during combustion. The fact was also brought forward by men of considerable experience that some of the Cu_2O invariably runs through the filter. (Fernand Gand, Compt. rendus CXIX, No. 10.)

Whatever the value or importance of the objections mentioned have been, there is no doubt that the Soxhlet-Allihn's method required a good deal of time. And that was the chief reason that urged me in the year 1894 and 1895, when I was engaged in sugar analysis for physiological purposes, to substitute a volumetric determination of Cu instead of converting the Cu_2O into metallic Cu and weighing as in the Soxhlet-Allihn's method. Either the Cy or "hypo" method could be applied.

I preferred the first simply because it requires a little less time, and as the only objection to it is the instability of the KCy solution, which did not prove very important. I examined the solution every week, but found no noticeable changes even in a month. I took an excess of Fehling's solution, as in Allihn's method. After the reduction of the copper I decanted the excess on an asbestos filter, and the main part of the residue was left in the evaporating dish. (In this way the losses during filtration were avoided.) I then washed the residue and decanted again; the oxide of copper in the dish and on the filter was dissolved by means of nitric acid, and the solutions united nearly neutralized with sodium carbonate and 5cc. of ammonia added; then the solution of copper was titrated with a standard solution of KCN.

All these manipulations take so little time that the determination of sugar is performed more rapidly than by the ordinary Fehling's method. (Especially if potassium ferro-cyanide is used for the determination of the end of the reaction.)

My experiments on pure crystalline anhydrous glucose, procured for me through the kindness of Dr. Vulté, gave the following results:

Glucose taken.	Glucose found.
0.057 gr.	0.0568
0.04635	0.0474
On pure cane sugar.	
0.0528	0.053
0.0528	0.053
0 08448	0.0845

This method was also tried by Drs. Vulté and Ward in the analytical Laboratory of the School of Mines in wine and chocolate analyses, and also by Mr. Sherman (under the direction of Dr. Vulté) in starch analysis. The results were very satisfactory.

When I invented this method I was ignorant of the fact that Mr. Kraus published the very same method some twenty-five years ago, in *Neuem Repertorium*, f. Pharm., 22, 89. The reason why the method has been scarcely noticed and almost entirely forgotten is inexplicable to me. Probably Mr. Kraus did not use asbestos for filtration. I desired to call the attention of the profession to this method, when I handed in this "note" to Dr. Vulté in April, 1895.

Lately Mr. Riegler applied the "hypo" method of Cu determination in sugar analysis, and published it as an entirely new method in the *Wiener Med. Blatter*, 1895, p. 348.

BOOK REVIEWS.

A Treatise on Surveying Comprising the Theory and the Practice. By WILLIAM M. GILLESPIE, LL.D., formally Professor of Civil Engineering in Union College. Revised and enlarged by Cady Staley, Ph. D., President of Case School of Applied Science; Part I, Land Surveying and Direct Leveling. New York, D. Appleton & Company, 1896.

Gillespie's Surveying through its many editions has always been the most scholarly work upon its subject published in this country. Professor Gillespie was an enthusiastic and thorough student, who not only recorded the latest practice of his time, in which he was personally experienced, but extracted all that seemed valuable from the older writers, and invented much that was new. He was, moreover, extremely careful and painstaking in the classification and arrangement in sequence of his gathered materials, so that his finished production was an eminently exhaustive and philosophical treatise.

Since the death of Professor Gillespie, it has devolved upon the present able editor of the work, to revise and enlarge it to meet the extended and changed requirements of modern practice, as successive editions were called for; and Doctor Staley gracefully acknowledges the indebtedness of his present work to the excellent foundation left by Professor Gillespie.

The portion devoted to the more advanced departments of surveying has now so much increased that it has been considered advisable in the present edition to issue the work in separate parts. Part I, which has already come from the press, is devoted to *Plane Surveying*, including *Land Snrveying* and *Direct Leveling;* Part II, which will shortly appear, will contain *Higher Surveying*, including *Trigonometric Leveling*, *Barometric Leveling*, *Precise Leveling*, *Topography*, *Geodesy*, *Field Astronomy*, *Hydrographical Surveying*, *Mining Surveying*, *City Surveying* and other special topics.

Part I makes a volume of 400 pages, besides appendices and tables,

from which has been exsected all matter relating solely to higher surveying, and the remaining topics have been rearranged, and some considerably amplified. As the book is so well known, it is only necessary to mention the important changes that appear in this edition. A fuller treatment of adjustments of theodolite, transit and level, is given; the Gradienter Attachment is described, and its use explained in the establishment of grades and the measurement of distances; a very clear exposition of the theory and practice of Stadia Measurement of horizontal and inclined distances appears; the Solar Compass and the Solar Attachment to the transit receive a careful treatment in the excellent chapter devoted to the laying out of public lands, as does also the method of establishing a parallel of latitude, which is a small circle of the sphere, by offsets from the line run by an ordinary transit, which traces out a great circle of the sphere.

The important subject of re-surveys is admirably discussed, and forms a very interesting chapter. The perplexing difficulties often presented on account of the obliteration of corner monuments and line marks, the inaccuracy of the early surveys, the ignorance of the old surveyors with regard to the declination of the needle, and the absence of data concerning the variation of the declination in some districts, are graphically described, and then follow some of the rules of law governing re-surveys, collated and classified by Judge Hugh J. Caldwell, for the guidance of surveyors. Judge Caldwell does not deliver an address, but presents forty-four rules, clear and terse, arranged in three classes, and covering the principal cases of uncertainty.

The chapter on Declination of the needle has been revised, while those on Fundamental Operations, Chain Surveying, Compass Surveying and Parting off and Dividing up land, remain much as they were.

The last chapter of the book is devoted to Direct Leveling, and is the best treatise on the subject, so far as it goes, that the reviewer has seen. The statement of principles is followed by an elaborate description of devices and instruments used in leveling, the various levels, adjustments, attachments and rods. Then comes the practice as exemplified in running a line of levels, with precautions and hints calculated to insure accuracy and expedition of work, forms of field-notes, observations on benchmarks and other pertinent matter. The converse operations of establishing lines of predetermined grades or elevations are also well, though too briefly, described. An interesting section sets forth the difficulties that may be encountered in running a line of levels, and advises how to overcome them. Among these are steep slopes, a pond too wide to be sighted across, a swamp, underwood, board fence, a wall, a house, a locality where the level cannot be set midway between the points sighted to, the effects of the sun upon the instrument, the effect of the wind and personal equation.

Part I. makes a very satisfactory treatise on Land Surveying and Leveling. J. W. D.

The Electrical Transmission of Energy. By ARTHUR VAUGHAN ABBOTT, C. E. New York, D. Van Nostrand & Co. 586 pp., 9 folding plates, 74 tables and 289 illustrations. Price, $4.50.

In this volume, Mr. Abbott has succeeded in presenting to the electrical profession the first book that contains complete, accurate and reli-

able data on the best systems of over-head and under-ground circuit work.

The opening chapters, after a short introduction on methods of distribution, treat of the properties of wire and include specifications that should be insisted upon when selecting wire.

Chapter III, covering 105 pages, is devoted to the construction of ærial circuits. This is divided into three parts and treats, in detail, general line work, electric railway circuits and lightning arresters.

The following chapter contains much valuable data on the construction of underground circuits, discussed under the two separate headings of "Conduits" and "Cables and Conduit Conductors."

In the next two chapters are found simple and detailed descriptions of measuring instruments and methods of employing them in electrical measurements. Even in this portion of the book, the practical character stands out forcibly in the omission of strictly physical methods and in the consideration of only such as are directly useful to the engineer.

Continuous current conductors are considered under the two sub-divisions of "Conductors and Insulators" and the "Heating of Conductors." Here the anthor takes occasion to insert considerable data in the shape of tables.

Chapter VIII, is on the subject of conductors for alternating currents and contains a simple, mathematical, but very clear discussion of the principles of alternating currents, illustrated by diagrams and practical examples.

The next 116 pages are taken up with series and parallel distribution. Here the author, after describing the detatls of the various systems, goes into the consideration of minimum first cost of line and station, minimum cost of maintenance, and maximum income. His deductions are based on Kelvin's law. It is in this treatment that the only real criticism on the book can be offered. The number of pages devoted to this subject is very apt to leave the impression that Kelvin's law is infallible, when, as a matter of fact, there is a great deal of uncertainty as to the true value of results obtained by it. There seems to be good reason for treating results obtained by applying calculus to financial questions with at least a great deal of suspicion

The last two chapters deal with miscellaneous methods of transmission, long-distance transmission, and the cost of production and distribution.

Taking it as a whole, the book contains matter that has been long sought after in so compact a form, and presented by an author whose name gives it the stamp of reliability. It contains information for the practical constructor, interspersed with sufficient theory and mathematics to make it valuable to the student and the engineer, and is therefore a valuable contribution to electrical literature. W. H. FREEDMAN.

Manual of Lithology, treating of the principles of the science, with special reference to Megascopic Analysis. By EDWARD H. WILLIAMS, JR. 8vo, pp. 418, plates I–VI. $3.

The book before us is stated on the title-page to be the second edition of the author's "Manual of Lithology," which was published ten or more years ago as a small volume of duodecimo size. It is so enlarged and expanded, however, that readers familiar with the first edition will find difficulty in recognizing it in the second.

The text is not divided into the customary chapters, but the general

division of the book among the several parts of the subject is somewhat as follows: It opens with an introduction of five pages, which controverts strongly the elevation of the dike-rocks into a separate group coördinate with the plutonic and the volcanic ones. The next eight pages are devoted to "Preliminary Description," under which head necessary definitions and methods of investigation without thin sections and the microscope are taken up. The rock-forming minerals follow at considerable length, occupying forty pages. Additional definitions follow, covering nearly forty pages more. The rocks themselves then fill almost three hundred pages, after which a scheme for determination, a discussion of the economic value of rocks, the usual index, and six half-tone plates, each of six cuts, complete the book.

Professor Williams groups all rocks into two great classes, the Primary and the Secondary. The Primary are practically those usually described as igneous or eruptive or massive, and the Secondary includes three divisions; the Débris Division, the Sedimentary Division and the Metamorphic Division. The subdivision of the Primary is not as is usual by feldspars, but into the Acid Division or Mica rocks, the Intermediate Division or Amphibole rocks, and the Basic Division or Pyroxene rocks. We cannot think that this is an improvement over the older method by feldspars. The ferro-magnesian silicates are by no means as characteristic of magmas as are the feldspars.

As each rock is taken up it is defined in brief and then discussed at length with notes on its geographic occurrence. The various species are given in great subdivision and it is evident that Professor Williams has read widely and compiled industriously. We think he has, if anything, overdone the collecting of terms, often of classic origin and not particularly significant for a book intended for the general student and for engineers. Some expressions seem to us capable of improvement. Thus in the description of Plates, figure 6 of Plate III, is described as "Microcrystalline quartz-porphyry (vesicular, porous pyroclastic breccia)" which really does not mean anything. Page 142, "Granite glass" is a contradiction of terms. Under Nevadite p. 110, and in several other places our author is a little unduly influenced by the amusingly critical attitude of our two great German petrographers Zirkel and Rosenbusch, toward each other. But aside from these minor points, the book furnishes a very complete record of the various kinds of rocks and will be found very useful as a hand-book and work of reference. All the rocks that are likely to be met are mentioned, to such an extent indeed, that one may question if on a megascopic basis all the distinctions can really be drawn by an observer. J. F. K.

Matte Smelting. Its principles and later developments discussed. By HERBERT LANG. Published by the Scientific Publishing Co., of New York. 1896.

Mr. Lang divides the subject of matting processes into the Blast Furnace and Reverberatory matting.

Under Blast Furnace matting is discussed the German system and Pyritic smelting, including in the latter the gradual reduction processes with hot and cold blast, and the Austin older process.

The work is divided as follows: Section I, The Carrier; Section II,

The Slags; Section III, Pyritic Smelting, and Section IV, Losses in Smelting, etc.

To those particularly interested in the subject of matte smelting, this work will prove of interest as it contains a general idea of what has been done in the various branches, but for the scientific public in general, many of Mr. Lang's discussions are rambling and tiresomely diffuse. His verbosity in many instances rendering the meaning obscure. A good feature of the work is the summary tables in section four, which give the characteristics of the different systems, the furnace effects, the materials treated and the products obtained. References to authorities freely quoted.

The book is bound in cloth covers with paper of poor quality. The number of pages with index is 96, and no illustrations are given. J. S.

DEPARTMENTAL NOTES.

ELECTRICAL ENGINEERING DEPARTMENT.

During the past academic year there have been introduced into this department several new methods, the successful operation of which demonstrates that others of a similar nature can and will be added with much benefit. Of these methods, that of preparing an extensive set of laboratory notes for the instruction of the Third Year class, has proved to be of much value, in so far as the time of the class, as well as their understanding of the subject are concerned. These laboratory notes are are to be improved and enlarged for subsequent work. All results obtained on tests are plotted in the form of curves, thus bringing to the student's mind a graphical representation of the action which is taking place between any two related quantities in a dynamo or motor.

A uniform size of note book has been adopted, and the endeavor made to show to the student the advantage of keeping the results in such form that he can refer to them in his future professional life with gain to himself.

The laboratory work for the Fourth Year students has been much improved and facilitated by the permanent location of the more sensitive instruments, so that the delicate and tedious adjustments of galvanometers have become almost unnecessary. Moreover, a set of ten blank forms covering as many experiments, has been in use during the year, greatly aiding the understanding of any particular method and making the interpretations of the results comparatively easy. The use of commercial instruments for this part of the laboratory work is encouraged, the only requirement being that all instruments be carefully calibrated. All results are shown in the form of curves, it being made easier to observe any peculiarities or locate any faults by this method than by the inspection of a table of observed values. The balance of the fourth year laboratory work is gradually being developed and improved upon, as new apparatus is procured.

In the lecture subjects a decided gain has developed from the fact that the students now have a complete text-book on the important subject of *Electric Lighting*, this book having been written by Professor Crocker with the idea clearly in mind of making it especially applicable for instruction in the class room.

A set of mimeograph notes on the design and construction of the different parts of dynamo electric machinery, containing many data, diagrams and drawings, has been issued by Mr. Sever for the use of the Third Year students.

A lantern and screen have been added to the lecture room equipment.

During the year Professor Crocker has delivered two lectures before the Henry Electrical Club, one dealing with "The Methods of Driving Dynamos," the other on "Troubles in Dynamos and Motors." A lecture on "The Exactness of Electrical Engineering" was delivered before the Franklin Institute, Philadelphia, while another on the "Operation of Different Electric Motors" was given before the Y. M. C. A. in New York City. A lecture on "The Electric Transmission of Power" was also given by Professor Crocker before the Engineering Society of Columbia University.

Mr. Sever has delivered before the Henry Electrical Club three lectures, as follows: "The Compound Dynamo," "Testing of Dynamos and Motors," "The Incandescent Lamp." A lecture on "The Electric Welding and Working of Metals," illustrated by experimental demonstrations, was given by him before the Engineering Society of Columbia University.

The purchase of a considerable number of measurrng instruments, such as voltmeters and ammeters, has greatly increased the facilities of the laboratory.

A 10-kilowatt Thomson electric welding machine has been obtained, thus affording an opportunity to show this interesting process of welding and working the various metals.

Some of the theses which have been undertaken by members of the Senior Class are as follows:

1. An investigation of the effect of different degrees of heat on the insulation resistance of various insulating materials employed in the construction of dynamo electric machinery.

2. Properties of various commercial lubricating oils under the wide range of speeds and pressures employed in dynamo practice. Electrical methods were employed for accurately determining the energy absorbed in friction.

3. Test of the electric lighting and power plant of the College of Physicians and Surgeons.

4. Test of a gas engine.

5. Construction of a contact maker for the investigation of alternating current waves and the plotting of a complete set of curves under widely different loads.

6. The electrolytic deposition of an alloy of gold and silver. Best conditions as regards to E. M. F. and current.

7. "The electromotive force between similar solutions of different concentrations.

DEPARTMENT OF MECHANICAL ENGINEERING.

By action of the Trustees at a recent meeting, an amendment to the statutes was approved, whereby there was recognized in the University organization the presence of, under the old name, School of Mines of Columbia College, a group of high grade special professional schools.

The feeling has been growing for some years that distinctive and honorable as the distinction "School of Mines" has been and is, it has prevented a large public from appreciating how much other and excellent work in a wide variety of departments was embraced under that one inclusive name, and that it was no real help to departments other than Mining that they should be conducted under a name which gave no inkling, save to the well-informed and initiated, of what the University was really doing and able to do. It was to correct the misapprehension and injury from these circumstances that the proposed action was taken.

The group of professors which has been designated as The Faculty of The School of Mines has received the new name of The Faculty of Applied Science. This faculty still has charge of the School of Mines which carries forward the historic name and prestige under which the University has won its fame in this field and in which shall be given the degrees of Engineer of Mines and Metallurgical Engineer, as formerly. The course in Geology has been made a variant or differentiation of the course in Mining.

Coördinate with the School of Mines is recognized the School of Engineering giving the degree of Civil Engineer, Electrical Engineer and Mechanical Engineer (the latter a new creation). The School of Architecture and the School of Chemistry are the third and fourth in the group.

This statutory change makes no alteration in the organization of the body of officers constituting the faculty which has been called heretofore the Faculty of the School of Mines, but it recognizes for popular and public use the manifold advantages accruing from the ability to designate by a name of expressive character the work which has been heretofore masked under a title too narrow to be expanded with the real growth of the University. It is not unlikely that at some future date the logic of analogy may bring about the sub-division of the School of Engineering into the component schools embraced within that designation, but for present and immediate convenience the inclusive term offers some advantages, and will be used until such growth or division may seem expedient and necessary.

It has been recognized for many years that development of the School of Mines to its pitch of excellence and numerical success on the present site of the College has rendered it impossible for the University to follow the trend of technical education in the Eastern colleges towards the development in a proper way of special courses for the education of mechanical engineers. It was rightly considered that until a proper equipment in laboratory, directions of shops and experimental appliances could be secured, that it was not the policy of the University to enter upon this field. This difficulty constituted one of the cogent conditions pointing to the necessity of a larger site for the University work.

It will be recognized on the other hand that the conditions of New York City, as one of the most important industrial centres in the country

and probably the most important professional centre for the work of engineers, was a location for the development of Mechanical Engineering than which none could be found more eligible. It has, therefore, been decided to establish a four years' course in the School of Engineering of the University to begin in the autumn of 1897 and to lead to the degree of Mechanical Engineer.

It will be recalled by all the graduates that the Professor of Mechanical Engineering has been laboring toward this end for many years, and they will rejoice with him in the final fruition of his desires. It is only to be regretted that so many years of waiting should have given a handicap which it will take Columbia some time to overtake.

The buildings upon the new site will furnish the necessary space for the laboratories of testing, heat engineering, hydraulic engineering, etc., and an extension of the arrangements existing between the University and the Teachers' College, permits the former to avail itself of the admirable and complete equipment of shop tools which form a feature of the Macy Manual Arts Building on 120th Street.

A special and characteristic feature of the accepted course in Mechanical Engineering has been the recognition of the principle of alternate courses in the final or senior year, whereby students may pursue that special line of study in the field of Mechanical Engineering for which their opportunities or circumstances may specially fit them, and at the same time secure a training of proper disciplinary and pedagogic value. By the plan of having the first three years common for all alternatives there is secured the principle of strength and yet the flexibility of the University organization. The three alternatives to be provided at once are the dynamic, the electrical and the mining alternative, others will be added later.

The manual or routine training is confined to the first two years of the course while the laboratory work of the two latter years is given a distinctly professional character that it may serve as a discipline as well as an earnest of high-class professional work.

A skillful assistance has been given to the development of the laboratory principle by the action of a representative manufacturing firm of New York City which has announced its intention to present to the Mechanical Laboratories a high grade form of steam-driven air-compressor. The design is technically known as a cross-compound, two stage air-compressor and is made a piece of laboratory apparatus of unsurpassed excellence.

The steam engine part permits of test and investigation upon the motor energy of steam, and the air-compressor part serves as a means of a giving convenient work to the steam engine to a considerable limit, while investigation upon the absorption of that work and its restoration by reconversion into mechanical energy permits the full thermodynamic and mechanical cycle of operations to be followed in detail by the student of its action.

The donor of this machine is The Ingersoll-Sergeant Drill Company of New York.

The coöperation of the graduates is earnestly desired in the line of securing for the new Mechanical Course, equipment in the way of gas and steam engine appliances, hydraulic motors and similar material.

Thesis work of engineering students in the class of 1896 in the

mechanical laboratory has included a comparative test of an Otto gas engine and a Hornsby-Akroyd oil engine for efficiency, for economy and for steadiness of running, the latter with a view to the availability of this form of motor for incandescent electric lighting. The tests have been by dynamometer and indicators and by metering the gas consumption, and have presented some novel features. An investigation as to the friction and durability of oils for lubrication has also been conducted, extending the use of the Thurston oil tester into some new fields.

The laboratory has added to its equipment a 10 horse-power De Laval Steam Turbine, which has been a centre of interest, by reason of the speed of the motor wheel, which reaches twenty-five thousand revolutions per minute. This will also be tested for efficiency in the near future.

TESTING LABORATORY.

Work in the Testing Laboratory for the year was active and has covered a wide range of materials.

The work of the students has been increased in amount and put upon as practical a basis as possible. They did their work in squads of three, beginning on the Fairbanks Machine where they made compressive tests of pine cubes, and short columns, finishing by making transverse tests of full-sized timber beams of pine, spruce and oak. They then made tensile and transverse tests of cast iron, wrought iron and steel, upon the Riehle machine, using the extensometer, deflectometer and other apparatus for measuring deformations, and from the data thus obtained they calculated the various results necessary for a complete test report. They also made tests of cast iron bars upon Keep's Transverse and Impact machines. The time occupied by each squad in this work was the afternoons for two weeks.

The scientific and commercial work of the laboratory has been especially active during the year. Over 200 tests have been made upon the Emery machine, and about 100 on the Riehl machine. Besides the ordinary tensile and compressive tests, which are a daily factor in testing laboratory routine, there have been several quite exhaustive investigations made of different materials which have involved much time and careful attention to detail.

Among the more important, from a purely scientific point, was an extensive series of tests to determine the elongation of cast iron under tension. This work was of a very delicate nature, and was only made possible by the sensitiveness and accuracy of the Emery Machine. The tests were made for Mr. W. J. Keep, of Detroit, in preparation of a paper upon the properties of cast iron which he presented to the American Society of Mechanical Engineers.

A set of tests to determine the effects of heat and cold in closing and opening the joints of heavy railroad rails, was also interesting and valuable.

Besides these, extended series of tests have been made upon the strength of vulcanized wood, concrete bricks, and one foot cubes of concrete, malleable iron eye bolts, Tobin bronze bars, bricks made from refuge ashes, building foundations, etc. Several of these investigations were made for different departments of the City Government, and some

for the U. S. Government, which is evidence of their public importance. Some are still in progress.

No special apparatus has been added to the laboratory during the year except a few measuring instruments, and testing appliances. One thesis upon the "Bearing Power of Soils" has involved considerable use by the student of one of the testing machines in making his determinations.

DEPARTMENT OF METALLURGY.

We have to record with regret that during the latter part of the term Professor Egleston has been seriously ill and confined to his home. He is slowly convalescing and expects to spend the summer in England. During his absence from college Dr. Struthers was in charge of the lectures and of the department.

In the second term the fourth class, under the direction of Dr. Struthers, visited the lead and copper works of the Balbach Smelting and Refining Co., at Newark, N. J.; the newly constructed copper and lead refining works of the Guggenheim Smelting and Refining Co., at Perth Amboy, N. J.; and the copper plant of the Nichols Chemical Co., at Laurel Hill, N. Y. We wish to hereby publicly acknowledge our thanks to the superintendents at these works for their courtesy in extending to us the privilege of visiting their works and their universal cordiality ot reception.

This new feature in the course of instruction is to be strongly commended, as thereby the students supplement the lectures with a practical view of the subject.

An optional summer school in metallurgy, under the supervision of Dr. Struthers, will be held at Butte, Mont., in July, at the expiration of the time devoted to the mining school. This region affords an excellent opportunity to study in detail the metallurgy of copper, lead, gold and silver. It is to be hoped that these trips will become permanent features of the course. Metallurgy is so eminently practical that it is absolutely necessary to supplement the lectures with work in the field, in order to obtain a rounded knowledge of the subject.

The investigations by Dr. Struthers on the expansion of special kinds of iron has been delayed on account of lack of proper furnace facilities. A special furnace is now being constructed to continue this important work.

The researches on the solubility of gold have been carried on by Dr. McIlhiney during the year. The results of his experiments will shortly appear in print.

The Department has received the following additions to the collection: A bronze tuyere, from Davis Bros. & Hartmann; a Sturtevant fan-blower; a suite of 38 specimens of metals, alloys and solders, collected in England; a model of the Blanton cam shaft; a suite of over a hundred specimens of refractory materials, crucibles, muffles, etc., showing English practice, and a few minor donations.

DEPARTMENT OF MINERALOGY.

Professor Egleston, the head of the Department, owing to severe illness, has been obliged to be absent during the latter part of the second term. Prof. Egleston will spend the summer abroad.

During the past year Professor A. J. Moses has been studying abroad, having taken his sabbatical year's leave of absence. Professor Moses has spent much of his time in Munich, and has also visited the famous mineral laboratories and collections, both on the continent and in England.

The work of instruction in the Department of Mineralogy for the past year has been in charge of Dr. Lea McI. Luquer

During Professor Moses' investigations in Munich he has devised, with the help of Dr. Weinschenck, a simple form of apparatus for measuring the indices of refraction of very small crystal faces by the Kohlrausch method of total reflection.

Last fall the Conference and Student collections were increased by the addition of some of the common minerals from the contact zones of the intrusive rocks and limestones in the northwestern part of New York State.

The equipment of the Department is to be materially increased during the coming year by the addition of new petrographical microscopes and other pieces of useful apparatus.

The more recent additions to the collection have been principally new and rare mineral species and varieties.

Dr. L. McI. Luquer and Dr. H. Ries have just completed their investigations on the "Augen-"gneiss area, near Bedford, N. Y., and will soon publish the report.

Dr. H. Ries has printed his investigations on the monoclinic pyroxenes of New York State.

Dr. Luquer expects during the vacation to complete his text-book on "Optical Mineralogy for Students," which will form one part of a series of books on Petrography to be published by Professor Kemp.

L. McI. L.

DEPARTMENT OF CIVIL ENGINEERING.

The past year has been one of marked advances for the Department of Civil Engineering. Without going into great detail regarding improvements in a number of the subjects given, it may properly be stated that the work done in botany for the first year, mechanical drawing in the second, the theory of railroad surveying in the third, and the design work in the fourth, have all added strength and excellence to the general course. Arrangements have been completed for the hydrographic survey on the Harlem River, in connection with current-meter work for tidal gaugings in the Harlem Ship Canal. A hydraulic laboratory is essentially completed, in which students will hereafter perform practical work in cubic measurements, flow in open channels and through orifices, friction in pipes and other hydraulic work that can advantageously be brought within the scope of laboratory practice.

The graduate course in Sanitary Engineering has been made an undergraduate course leading to the degree of Civil Engineer. A large part of the former graduate course has already been absorbed into the regular course in Civil Engineering. The special undergraduate course in Sanitary Engineering has, therefore, by an easy and natural step, been such a differentiation from the general course in civil engineering consistently with the broad character of the latter. Special developments in biology, bacteriology and chemistry in their relations to public health, and sani-

tary questions in general, have been secured without neglect of the essentials of professional civil engineering study. It is believed that the interests of the whole department will be served by this change.

GEOLOGICAL DEPARTMENT.

Professor Kemp left on May 28th, with the students of the Summer School of Mining and Geology, for Butte, Mont. The class stopped, *en route*, three days, at Lockport and Niagara Falls, so as to make a geological section of the Silurian rocks which are so well exposed at those points and in the outskirts of Buffalo. They went thence to Butte, via the Union Pacific and the Oregon Short Line, halting one day at Green River, Wyo., to visit the coal mines. Four or five days were spent in surface work at Butte, after which the class went to Professor Peele for the work in Mining. Professor Kemp returned via the Yellowstone Park and the Black Hills and made collections of rocks in each place for the Department. The remainder of the vacation will be largely passed by him in field work in the Adirondacks, and in August he has volunteered to conduct a party of the Fellows of the Geological Society of America, and of the American Association for the Advancement of Science, through the most interesting geological exposures in the eastern Adirondacks.

Mr. Hollick will continue his field work on the Cretaceous geology and paleobotany along Long Island Sound and on Staten Island. Some interesting discoveries have been made which need further investigation.

Mr. Van Ingen will make a long collecting trip of about six weeks' duration, beginning in June. He plans to visit localities in Indiana, Missouri, Arkansas and Tennessee, from which materials are needed to fill out gaps in our museum, and to be used in connection with investigations now in progress in the Department. Later in the vacation Mr. Van Ingen plans to complete an investigation now in progress on the faunas of a portion of the Siluro-Devonian strata in New York.

Mr. T. G. White's thesis on the Trenton faunas of the Lake Champlain valley will be finished during the coming year, as it has been found advisable to visit the region again, and to make even more complete collections than last year. The work has proved of especial interest in that the faunas connect those of central New York with those of the St. Lawrence valley. Since the issue of the last bulletin, the Department has acquired by purchase one of four existing collections of marine Tertiary fossils that were made from the drillings of the deep artesian well at Galveston, Texas. A valuable series of Devonian fossils, mostly molluscs and fish, have been obtained by exchange with Mr. F. A. Randall, of Warren, Penn.

For very acceptable additions in various lines of economic geology, the Department is indebted to Mr. H. Ries, '92, and Mr. A. L. Colby, '81, for which this opportunity of expressing grateful acknowledgments is taken. A fine model in plaster of the Tilly Foster Mine has recently been received from the Lackawanna Steel Co., and a good illustrative set of asphalts from the Barber Co.

UNIVERSITY NEWS.

The formal celebration of the removal of the University to the new site took place May 2, as all the graduates have doubtless been informed

by circulars before this. The exercises began at 11:30 with a parade of the trustees, teaching staff, invited guests and alumni, from the South Hall along the east side of the new library to the corner-stone of the Physics building, at the northwest corner of its foundation. President Low made a few introductory remarks, Rev. Dr. Coe read the prayer, Prof. Rood laid the stone, and Prof. Van Amringe delivered a very appropriate address. The procession then re-formed and marched to the southwest corner of Schermerhorn Hall, where again President Low made a brief introductory address, which was followed by the reading of the appropriate prayers and responsive service by Rev. Dr. Dix, by the laying of the stone by Mr. Wm. C. Schermerhorn, the donor of the building, and by an address from Prof. H. F. Osborn that was a most felicitous expression of the thoughts and feelings that were uppermost in the minds of the scientific professors of the University. A lunch was then spread in a tent for the trustees and teaching staff and another in West Hall for the graduates.

At 2:30 in the afternoon the dedicatory exercises of the new Library were celebrated in a great tent that had been spread at its south entrance, just below the high retaining wall that will ultimately be covered by the approaching steps of the Library. The tent was built to hold 5,000 people, and it was crowded. Immediately before the platform that was reserved for the speakers, trustees and invited guests, were located the undergraduates of Columbia and Barnard and the graduate students. Back of these, in the centre of the rising tiers of seats, were the alumni. On their left came the faculty families, and still further to the left the teaching staff. On the right of the alumni were the friends and guests of the University, and at the extreme right a space was reserved for Lafayette Post of the Grand Army, the one that presented the National colors to the University. The arrangements were exceptionally good, as each particular party marched in from a different door and reached its seat without confusion. Great credit is due Mr. Darling, the superintendent of the University property, for his efficient plans and for their smooth execution. While the audience filed in, the Seventy-first Regiment marched upon the terrace at the rear of the speaker's platform, in full dress uniform, and later Lafayette Post took its place in front of them. The scene was one never to be forgotten, the caps, gowns and many hued hoods of the trustees, guests, faculties and students, the students and alumni, with their recurring college cries, the gay dresses of the ladies, and back of all the ranks of troops, all combined to make it extremely striking. The exercises opened with prayer by the Rev. Dr. Coe. President Low followed with an address that was not only wonderfully well chosen, but that at times was decidedly eloquent. The President turned to a very happy use the presence on the plateau of the Cathedral, the Hospital, the University and the tomb of General Grant, representing the impressive combination of religion, philanthropy, learning and patriotism, placed high above and in full view of the busy city. The Glee Club and audience then sang the Latin ode written by Professor Peck for the occasion, and even the Mines men made an earnest try at it. The stand of colors was then presented to the University on behalf of Lafayette Post by Rear Admiral Meade, in an address that appealed strongly and effectively to the patriotic feelings of all present. President Low responded, and then all rose and uncovered while the regimental band

played "The Star Spangled Banner." The Post has promised with the colors a suitable staff in a bronze pedestal, which is to be located in the centre of the plaza before the great library. Probably in term time the flag will regularly be displayed.

The principal oration was then given by the Hon. Abram S. Hewitt. As the address proceeded, Mr. Hewitt's voice failed him somewhat so that his words were not everywhere audible and the audience generally look forward to reading the address in print. President Eliot followed with a brief address of congratulation from sister institutions it being appropriately given by him, for as time proceeds Harvard, Columbia, Pennsylvania and Chicago are more and more assuming the leading university positions in this country. as the combination of large means and a city location makes inevitable. The exercises closed with the benediction by Bishop Potter. Altogether the day was one long to be remembered as a most appropriate and emphatic celebration of Columbia's great advance in late years. J. F. K.

The Trustees have recently passed legislation that has for years been pending and inevitable and that is at last settled in a manner satisfactory to all concerned. It has been obviously unfair to Civil and Mechanical Engineering, to Chemistry and Architecture, all of which have special courses, to be grouped under the name School of Mines. The trustees have accordingly instituted new schools respectively of Engineering, Chemistry and Architecture, and have kept the School of Mihes as comprising the courses of Mining Engineering and Metallurgy. Not to multiply faculties unduly, they have placed them all as before under a combined faculty, that will hereafter be known as the Faculty of Applied Sciences. This solution of an old time and vexatious question is the fairest possible for all concerned, and as above stated gives general satisfaction.

It raises, however, some interesting questions, as for instance, what is the proper future name of our Alumni Society, and what is the best and most appropriate name for the SCHOOL OF MINES QUARTERLY. Although no immediate change in either of these is probable, the question will of neeessity come up in time. J. F. K.

Professor Britton has been elected Director in Chief of the recently established New York Botanical Garden and has of necessity resigned his professorship to accept. He will, however, be continued as professor emeritus as a token of appreciation for his singularly successful work in our department of Botany. While regretting Dr. Britton's severance of active relations with Columbia, the QUARTERLY extends to him its best wishes that the work of one of its former editors may be equally successful in his new and exceptionally promising field of usefulness.

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An advanced course prepares students for the Second Year Class of the School of Mines.

Four hundred Students of Columbia School of Mines have been instructed in the Woodbridge School. Also a large number have been prepared for Massachusetts Institute of Technology, Stevens Institute, Sheffield Scientific School, Lawrence Scientific School, Troy Polytechnic Institute, Cornell University, and the Classical, Medical and Law Departments of Harvard, Yale, Columbia and Princeton.

LISTS OF THE ALUMNI

OF

COLUMBIA COLLEGE

SCHOOL OF MINES.

1896.

MEMBERS OF THE ALUMNI ASSOCIATION AND OTHER GRADUATES
DETECTING ERRORS IN THE SUCCEEDING LISTS
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PROF. F. R. HUTTON,
SECRETARY,
COLUMBIA UNIVERSITY SCHOOL OF MINES,
OR TO
No. 12 WEST THIRTY-FIRST STREET.
NEW YORK CITY.

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CONSTITUTING THE

BOARD OF MANAGERS

OF

THE ALUMNI ASSOCIATION OF THE SCHOOL OF MINES.

1896.

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WILLIAM ALLEN SMITH, '68.
52 Wall Street, N. Y.

Vice-President,
JAMES FURMAN KEMP, '84.
Columbia University, N. Y.

Secretary,
F. R. HUTTON, '76.
Columbia University, N. Y.

Treasurer,
LEA McILVAINE LUQUER, '87.
Columbia University, N. Y.

MANAGERS.

Terms expire 1896.	Group.	Terms expire 1897.
J. C. F. RANDOLPH, '69.	I.	WM. A. HOOKER, '69.
NATH. L. BRITTON, '79.	II.	W. M. MESEROLE, '81.
LEA McI. LUQUER, '87.	III.	DANIEL E. MORAN, '84.
J. M. HEWLETT, '90.	IV.	H. K. MASTERS, '94.

NOTE.—Correspondence concerning dues and other clerical details of the work of the Association may be conveniently addressed to MR. FRANCIS W. HOADLEY, Assistant to the Secretary and Treasurer, No. 12 West 31st St., New York City.

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(REVISED TO APRIL, 1896.)

LIST No. 1.

Contains the names of all Graduates and Members of the Alumni Association grouped by classes from the beginning. The details as to residence and Professional Occupation are given in the second or alphabetical list for convenient reference.

(REVISED TO APRIL, 1896.)

CLASS LIST

OF

GRADUATES AND MEMBERS

OF THE

ASSOCIATION OF THE ALUMNI.

[NOTE.—Where the name is followed by a date, it denotes that the person is no longer living, and the date is the year of the death.]

1867.

Adams, J. M., 1892.
Bridgham, S. W.
Bronson, E. S.
Brown, F. G.
Church, J. A.
Cornwall, H. B.
Giddings, E. E.
Gracie, C. K., 1891.
Hale, A. W.
Harding, G. E.*
Harmer, T. H.
Petit, F. M.
Tuttle, W. W.
Van Lennep, D.

1868.

Barnard, A. P.
Baxter, G. S.
Carson, J. P.
Chester, A. H.
Coursen, G. H.
Geer, G. J., Jr.
Hanna, G. B.
MacMartin, A., 1881.
Melliss, D. E.*
Moffatt, E. S., 1893.
Parsons, G. H.
Pennington, J. P.*
Pistor, W.
Platt, C. S.
Robertson, K.
Shack, A. P.
Schermerhorn, F. A.
Smith, L.
Smith, W. A.
Stalknecht, F.
Van Arsdale, W. H.
Wheeler, M. D., 1889.

1869.

Blossom, T. M., 1876.
Bruckman, F.
Campbell, A. C.
Delafield, A. F.*
Hooker, W. A.
Huntingdon, C.
Irving, R. D., 1888.
Jenney, W. P.
Munroe, H. S.
Nettre, L. R.
Newton, H., 1877.
Potter, W. B.
Randolph, J. C. F.

1870.

Haight, O., 1891.
Ingersoll, W. H.
Knapp, J. A.
Lilienthal, J. L., 1893.
Lindsley, S.
Parrot, E. M.
Terhune, R. H.
Van Wagenen, T. F.
Waller, E.

---

* Associate.

1871.

Fales, W. E. S.
Goldschmidt, S. A.
Gordon, J.
Ricketts, P. de P.
Riggs, G. W.
Roberts, G. S.
Robertson, R. S., Jr.

1872.

Austen, P. T.
Jenney, F. B., 1876.
McDowell, F. H.
Sloane, T. O'C.
Wendt, A. F., 1893.

1873.

Canfield, F. A.
Colton, C. A.
Mott. H. A.
Webb, H. W.
Williams, J. T., Jr.

1874.

Allen, C. S.
Renedict, W. de L.
Cameron, J. G. M., 1889.
Ledoux, A. R.*
Lillie, S. M.
Murray, G.
Olcott, E. E.
Rees, B. F.
Rhodes, F. B. F.
Williams, F. H.

1875.

Ihlseng, M. C.
Iles, M. W.
Jackson, C. E.
Joy, D. A., 1888.
Lamson, R., 1876.
Leavens, H. W.
Macy, A., 1891.
Noyes, W. S.
Pfister, P. C.
Putnam, B. T., 1886.
Rees, J. K.
Rolker, C. M.
Russell, S. H., 1889.
Stewart, H.
Thompson, M. S.
Tucker, J. H.
Vanderpoel, F.
Wells, J. S. C.
Wetmore, E. A.
Wright, A. A.

1876.

Austin, T. S.
Bruen, F. E., 1884.
Cornwall, G. R.
Craven, F. C., 1890.
Foote, H. C., 1888.
Garrison, E. H.
Gratacap, L. P.
Hall, R. W.
Hamilton, S., Jr.
Holbrook, F. N.
Hoyt, W. L.
Hunt, F. F.
Hutton, F. R.
King, C.
Lord, N. W.
Love, E. G.
Maghee, J. H.
Morewood, H. F.
O'Grady, J. W., 1890.
Randolph, J. F.
Ross, W. C.
Schneider, A. F.
Tilden, G. C.
Van Blarcom, E. C.
Walbridge, A. C., 1892.
Wardlaw, J. R., 1891.

1877.

Barros, L. de S.
Barus, C.
Beard, J. T.
Behr, E.
Buckley, C. R.
Cady, L. B.
Canfield, A. C.
Cauldwell, J. B.
Clark, H. G., 1881.
Colby, C. E.
Constant, C. L.
Cornell, G. B.

* Associate.

Floyd, F. W.
Helleberg, F. S., 1883.
Hildreth, W. E.
Ihlseng, A. O.
Jordao, J. N. P.
Kelly, W.
Mackintosh, J. B., 1891.
Martin, E. W.
Murphy, J. G.
Nichols, R.
Norris, D. H.
Priest, J. R., 1880.
Radford, W. H.
Reed, S. A.
Rogers, C. L.
Sage, E. E.
Smeaton, W. H.
Smythe, R. M.
Thacher, A.
Van Boskerck, R. W.
Waterbury, C. R.

1878.

Adams, W. J.
Benjamin, M.
Blydenburgh, C. E.
Booraem, R. E.
Brinkerhoff, G. C.
Butler, W. P.
Cushman, A. R.
Davis, J. W.
Devereux, W. B.
Downing, O. P.
Drummond, I. W.
Eliot, W. G.
Fernekes, A., 1884.
Haas, H. L.
Hasegewa, Y.
Hodges, H. A., 1883.
Holden, E. H.
Hollis, W.
Johnson, E. M.
Johnson, G. H.
Karr, C. P.
Lawrence, B. B.
Lyman, F.
Matsui, N.
McCulloh, E. A.
Morewood, G. B.
Morris, G. W., 1895.
Munsell, C. E.
Murphy, H. M.
Nambu, K.
Newberry, S. B.
Noyes, J. A.
Olmstead, O. F., 1881.
Owen, F. N.
Palmer, C. E.
Parker, R. A.
Pazos, V. F.
Perry, N. W.
Strieby, W.
Willis, B.

1879.

Bolton R.
Britton, N. L.
Cloud, L. G.
Cornwall, H. C.
Deluze, L. P.
Eastwick, G. S.
Haffen, L. F.
Harker, C. S.
Hathaway, N.
Hollerith, H.
Hollick, C. A.
Johnson, I. B.
Johnston, R. A., 1895.
Koch, E. C.
Leggett, T. H.
Ludlow, E.
Marsh, C. W.
Mathis, T. S.
Mayer, R. E.
Merwin, H. J.
Milliken, G. F.
Munroe, O. M.
Neftel, K.
Nesmith, J.
Noble, C. M.
Reed, W. B. S.
Rhodes, R. D.
Rutherford, F. M.
Sheldon, G. H., 1889.
Starr, H. F.
Stewart, F. B., 1879.
Stone, G. C.
Suydam, J. R., Jr.
Williams, G. W.

1880.

Beebe, A. L.
Benjamin, F. P., 1893.
Browning, F. D., 1885.
Brugman, W. F.
Butler, N.
Churchill, A. D.
Clark, E. P.
Elliott, W.
Engel, L. G.
Francke, R. O.
Garlichs, H.
Greene, W. U.
Greenleaf, J. L.
Hallock, A. P.
Hendricks, H. H.
Hooper, L. M.
Hopke, T. M.
Hudson, E. H.

Klepetko, F.
Kunhardt, W. B.
Mattison, J. G.
Meissner, C. A.
Merritt, J. H.
Navarro, J. A.
Parker, A. McC.
Parks, J. R.
Robinson, H. A.
Ruttman, F.
Singer, G.
Singer, G. H.
Smalley, W. A. 1886.
Smith, M.
Tonnelê, T.
Torrey, C. H., 1895.
Walker, J., Jr.
Wheeler, H. A.

1881.

Andresen, C. A.
Aschman, F. T.
Bleecker, C. P.
Braschi, V. M.
Bush, E. R.
Chazal, P. E.
Colby, A. L.
Curtis, C. G.
Douglas, E. M.
Dunham, E. K.
Elliott, A. H.
Furman, H. V. F.
Griswold, W. T.
Hemmer, F. A.
Judd, C. B.
Leary, D. J.
LeBoutillier, C.
Ledoux, A. D.
Little, W. P.
Meserole, W. M.
Neymann, P.
O'Connor, M. J.
O'Connor, T. D.
Pitkin, L.
Raymer, G. S.
Richmond, W. T.
Roberts, A. C.
Sawyer, C. P.
Share, W. W.
Starr, C. D.
Stearns, T. B.
Swain, A. E.
Tuttle, E. G.
Van Sinderen, A. H.
Vulté, H. T.
Wiechmann, F. G.
Williams, W. F.
Wilson, H. M.

1882.

Calman, A.
Conant, T. P., 1891.
Cooper, W. H.
Crocker, F. B.
Dougherty, O. V., 1889.
Downes, S. B., 1895.
Downs, W. F.
Emrich, A. F., 1893.
Falk, D. B.
Feuchtwanger, H.
Fitch, C. L.
Going, C. B.
Hill, W.
Illig, W. C., 1894.
Joüet, C. H.
Mesa, A. E.
Moses, A. J.
Oothout, E. A., 1894.
Page, W. S.
Parsons, W. B.
Payne, C. Q.
Porter, J. B.
Powers, C. V. V.
Sands, F.
Shumway, W. A., 1892.
Staunton, W. F.
Stockwell, N. S.,1888.
Toucey, D. B.
Traphagen, F. W.
Vondy, R. H.
Wainwright, J. H.
Wainer, A. G.
Ward, N. R.
White, W. S.
Wilson, W. A.
Wittmack, C. A.
Young, E. L.

1883.

Abeel, G. H.
Adams, R.
Ayestas, A.
Balch, S. W.
Banks, J. H.
Bardwell, A. F.
Brereton, T. J.
Brewster, H. D.
Browning, J. H. B.*
Bullman, C.
Carrére, J. M.
Channing, J. P.
Endicott, G. 1889.
Ferrer, C. F.
Ferris, J. C.
Fiallos, E. C.
Haasis, D. F.
Humbert, W. S.

* Associate.

Lilliendahl, A. W.
MacTeague, J. J.
McKenna, C. F.
Oxnard, J. G.
Painter, G. E.
Paraga, C. F.
Peele, Robert.
Powell, F.
Randolph, E.
Renault, G.
Rich, J. M.,
Richardson, J. C.
Ridsdale, T. W.
Suter, G. A.
Tibbals, G. A.
Tower, A. E.
Walker, A. L.
Weed, W. H.

1884.

Adams, W. C.
Alden, H. C.
Baldwin, W. M.
Barnard, E. C.
Barratt, E. G.
Bodelsen, O.
Brinley, J. R.
Bryce, W.
Buckingham, F. E.
Burritt, W. W.
Corcoran, J. T.
Del Calvo, F.
Duncan, W. P., 1889.
Dusenberry, W. T.
Easton, L. C.
Fahys, G. E.
Fitch, J. H.
Fitzgerald, G. E.
Fowler, S. S.
Glover, C. G., 1888.
Gosling, E. B.
Griffin, S. P.
Gross, L. N.
Horn, J. T.
Kemp, J. F.
Lamb, A. J.
Luttgen, E.
McGenniss, J. W., Jr., '90.
McKim, R. A.
McLoughlin, C. S.
Miller, C. W.
Moeller, W., 1887.
Moran, D. E.
Morgan, W. F.
Mulford, R.
Napier, A. H. 1895.
Newberry, W. E.
Newbrough, W.
Nolan, T.
Northrop, J. I., 1891.
Nye, A. C.
Painter, C. A.
Pearis, C. F.
Pellew, C. E.
Post, A. S.
Powers, L. J.
Proctor, W. R.
Reckhardt, D. W.
Roeser, F.
Rood, R. G.
Bowland, C. B.
Rupp, P., Jr.
Schöney, E., 1888.
Sherman, F. D.
Slack, C. G.
Smedberg, H. A.
Snook, T. E.
Speyers, C. L.
Tibbals, S. G.
Value, B. R.
Walbridge, F. K.
Wood, G. E.

1885.

Amy, E. J. H.
Barkley, H. F.
Bemis, F. P.
Brennan, A. J.
Bush, W. F.
Cary, G.
Clark, F. S.
Cozzens, H.
Crowell, C. B.
Detwiller, C. H.
Doolittle, C. H.
Dwight, A. S.
Eddie, E. C.
Engelhardt, E. N.
Graff, C. E.
Hart, B.
Hawkes, E. McD.
Hildreth, R. W.
Hollis, H. L.
Huntington, F. W.
Ingram, E. L.
Johnson, A. G.
Lacombe, C. F.
Lee, G. B.
Mannheim, P. A. L.
Marié, L.
Meyer, H. H. B.
Merrill, F. J. H.
Miller, C. L.
Moldehnke, R. G. G.
Noble, L. S.
Norris, R. V. A.
Page, G. S.
Pierce, H. N.
Polledo, Y. Y.
Sanders, W. E.
Shope, H. B.
Starek, E.
Struthers, J.
Thomas, F. M.
Titus, W. H.
Van Cortlandt, E. N.
Watson, F. M.
Whitman, E. P.
Wiltsie, E. A.
Woolson, I. H.

1886.

Agramonte, E., Jr.
Agramonte, J. C.
Bell, H. M., Jr.
Berry, W. G.
Casey, E. P.
Conant, H. D.
Edwards R. M.
Frankfield, E.
Good, G. McC. H.
Horne, W. D.
Howe, E.
Janeway, J. H.
Jenks, A. W.
Kissam, H. S.
Lederle, E. J.
Lee, H. C.
Newhouse, E. L.
Norton, L. H.
Ormsbee, J. J.
Osterheld, T. W.
Peck, S. B.
Porter, H. H., Jr.
Ryon, A. M.
Spooner, A. N.
Stodder, R. H., 1887.
Stuart, W. H.
Thompson, H. C.
Trowbridge, S. B. P.
Van Brunt, A. H.
Von Nardroff, E. R.
Wallace, W. J.
Wheatley, J. Y.
Wilson, C. E.

1887.

Aldridge, W. H.
Appleby, W. R.
Bellinger, H. P.
Bien, J. R.
Burns, A. L.
Burns, E. Z.
Butler, W. C.
Church, E. D.
Cole, H. M.
Congdon, E. A.
Cox, J. S., Jr.
Darwin, H. G.
Davis, C. H.
Donnell, H. E.
Ferguson, W. C. A.
Gage, S. E.
Goldsmith, B. B.
Gudeman, E.
Heinsheimer, A. M.
Huntting, H. O.
Jacobs, D. M.
Jacobs, S. J.
Jeup, B. J. T.
Lahey, J.
Lahey, R.
Luquer, L. McI.
Lusk, G.
MacKaye, H. S.
Mannheim, H. C.
Marsh, J. R.
Middleton, J.
Moeller, R.
Muller, G.
Nichols, H. P.
Primelles, J. A.
Restrepo, C. C.
Rice, G. S.
Rowland, G.
Rutherford, L. H.
Schieffelin, W. J.
Seligman, J. G.
Simonds, F. M.
Slade, R. E.
Stanton, F. McM.
Staunton, J. A. Jr.
Stevens, A.
Tower, F. W.
Trask, G. F. D.
Tyler, W. L.
Warner, J. L.
Wels, P. O.
Wertheimer, L.

1888.

Allen, R. L.
Appleby, J. S.
Baker, G. L.
Bartlett, F. R.
Bechstein, C. A.
Beckwith, C. E.
Berry, G.
Brewster, H. D.*
Browning, J. H. B.*
Colt, S. B.
Comstock, C. N.
Dodge, F. D.
Dodsworth, W. A.
Dow, A. W.
Fisher, W.
Frank, J. W.
Gardner, W. D.
Hebert, O. B.
Hopke, F. E., 1890.
Jones, W. D.
Koen, J. J.
Lenox, L. R.
Lipps, H., Jr.
McIlvaine, A. R.
Maclay, J.
Miller, R. P.
Morgan, J. L.
Munoz del Monte, A. C.
Parker, O. B,. 1891.
Parsons, H.
Percival, G. S., 1892.
Perkins, T. S.
Schumann, C. H.
Shriver, H. T.
Smith, F. P.
Smyth, C. H., Jr.
Stoughton, A. A.
Taylor, J. B.
Tucker, A.
Van Dyck, E.
Van Volkenburgh, E.
Volckening G. J.

* Associate.

1889.

Wampold, L.
Ward, D. W.
Atha, H. G.
Berry, G.
Brown, R. G.
Gramer, S. W.*
Cromwell, J. W.
Denton, F. W.
Dresser, D. LeR.
Eastwick, E. P.
Eilers, K. E.
Ellis, A. V. H.
Escobar, F.
Fearn, P. LeR.
Fowler, A. C.
Freedman, W. H.
Gifford, S. D.
Griffith, V. C.
Griggs, W. E.
Guiterman, E. W.
Harrington, T. H.
Harris, E.
Heinze, F. A.
Holt, M. B.
Ives, A. S.
Jopling, R. F.
Luquer T. T. P.
Mahony, A. S.
Mapes, C. H.
Mason, C. S., 1889.
Massa, C. G.
Matthews, C. T.
Monell, J. T.
Mosley, R. K.
Oseransky, I. H.
Piez, C.
Post, A. Van Z.
Preston, W. E.
Provost, A. J., Jr.
Provot, G.
Raymond, R. M.
Raynor, R.
Rogers, O. L.
Schroeder, J. L.
Skidmore, S. T.
Small, F. M.
Smith, A.
Smith, F. M.
Stoughton, C. W.
Waters, G. S.
Wedeking, E. H.
Weekes, E. F., 1893.
Weeks, W. H.
Whitlock, H. P.

1890.

Andrews, S. W.
Beckwith, G. A.
Behlen, H.
Betts, R. T.
Black, A. L.
Blake, E. M.
Book, D. D.
Bradley, S. R.
Buckland, W. A.
Cairns, F. I.
Carson, J.
Clark, D. L.
Clayton, W. R.
Colton, F. G.
Connell, H. R., 1895.
Coykendall, T. C.
Davis, W. M.
Deghneé, J. A.
Douglas, J. S.
Ferguson, G. A.
Fisher, L. W.
Foyé, A. E.
Gildersleeve, A. C.
Gould, E. L.
Gudewill, C. E.
Hart, C. H.
Hewlett, J. M.
Hicks, G. J., 1891.
Hinman, B. C.
Hooper, F. C.
Hoyt, J. S.
Hurlburt, E. D., Jr.
Jarmulowsky, M.
Jones, J. T.
Kohn, R. D.
Korn, L.
Levy, A. L.
Lichtenstein, E. G.
Lowndes, W. S.
McKleroy, W. H.
Mann, H. B.
Massa, L. F.
Meikleham, T. M. R.
Montenegro, M. R.
Parker, H. C.
Pearce, R.
Pelton, H. C.
Portuondo, J.
Post, W. S.
St. John, T. M.
Steers, J. R.
Thorne, W. L.
Warren, C. P.
Welch, A. McM.
Welsh, H. F.

1891.

Anderson, Geo.
Bliss, C. P.
Blossom, F.
Boecklin, W.
Boyd, R. C.
Brosnan, F. X.
Cristy, E. B.
Dunn, G. S.
Eberhardt, Wm. G.
Goodwin E.
Hawley, J. F.
Holter, N. B.

* Associate.

Hornbostel, H. F.
Keeler, F. S.
Kinsey, F. W.
Langthorn, J. S.*
Leary, Geo.
Lilliendahl, F. A.
Livingston, A. R.
Mahl, J. T.
Mann, C. R.
Miller, E. H.
Mora, M. L.
Owens, R. B.
Raymond, A.
Skinner, E.
Strout, W. A.
Thomas, F. C.
Totten, G. O., Jr.
Tuska, G. R.
Warren, L.
Watson, R. B.
Wiener, Wm.

1892.

Ansbacher, L. A.
Anthon, A.*
Bergen, C. H.
Bolles, R.
Burden, H., 2d.
Casamajor, G. H.
Clark, Edmund.*
Clarke, W. C.
Covell, E. C.
Curtiss, C. C.
Dolan, C. F.
Dufourcq, E. L.
Durham, E. B.
Dutcher, B. H.
Fenner, C. N.
Friedman, S.
Gillette, H. P.
Granger, A. D.
Harrison, N.
Hay, A.
Herckenrath, W. A.
Jackson, O.
Kletchka, J. J.
Knox, C. E.
Livingston, G.
Longacre, L. B.
Lord, F. R.
McIlhiney, P. C.
McKinlay, J. B.
Meisel, F. C. A.
Merz, E.
Parmly, C. H.
Pierce, F. E.
Reckhart, G. F.
Reese, W. W.
Ries, H.
Rosenthal, A.
Savage, S. M.
Southard, G. C.
Temple, S. J.
Towart, J.
Van Ingen, D. A.
Werner, H. C.
White, R. D.
Windecker, C. N.
Windolph, A. P.

1893.

Agelasto, M. A.
Agramonte, I. E.
Aldrich, C. H.
Ayers, W. C.
Behrman, G. W.
Bossange, E. R.
Brooks, W. F.
Canfield, M. C.
Clark, G. H.
Covell, W. S.
Foster, R. G.
Gonzalez, A.
Gregory, L. E.
Hankinson, A. W.
Harte, C. R.
Haskell, H. G.
Hoyt, R.
Hume, F. T.
Hyde, F. S.
Jones, J. E.
Kurtz, E. L.
Langmuir, A. C.
Liebmann, A.
McKee, H. S.
Macy, V. E.
Malukoff, A. J.
Matthew, W. D.
Newton, T. M.
Oakes, J. C.
Pederson, F. M.
Pomeroy, W. A.
Post, R. B.
Prince, A. D.
Provot, F. A.
Putnam, B. R.
Reynolds, M. T.
Robinson, F. G.
Schroter, G. A.
Smith, H. A.
Thompson, S. C.
Tilghman, H. A.
Tuttle, W.

1894.

Acken, B. A.
Barnett, L. K.
Black, Adolph.
Bogert, M. T.
Chapman, A. W.
Clark, Leroy.
Cokefair, F. A.
Emery, H. G.
Fellows, Wm. K.

* Associate.

Folger, E. P.
Frisbee, H. D.
Fuentes, Paul.
Greene, D. J.
Hass, E. F.
Hamilton, F. C.
Hanson, R. C.
Harold, A. P.
Jacobs, H. A.
Jones, E. M.
Kastner, J. C.
Leeming, T. L.
Libaire, E. W.
McNeil, C. R.
Masters, H. K.
Messiter, E. H.
Meyer, Joffe.
Mears, G. K.
Morris, B. W., Jr.
Murchison, K. M.
Munroe, M.
Osterberg, Max.
Pope, J. R.
Prince, J. L.
Rennard, J. C.
Rittenhouse, C. T.
Searle, C. D.
Seldner, R.
Self, E. D.
Sherman, G. F. G.
Smith, W. F.
Steinam, J. L.
Stratton, Alex.
Taintor, W. N.
Tennille, G. F.
Tompkins, J. A.
Vail, L. H.
Vanderbilt, W. D.
Vatable, J. J.
Walker, H. V.
Ware, F. B.
Westervelt, W. J.
White, T. G.

1895.

Alexander, J. A.
Andrews, W. C.
Archer, G. F.
Albertson, A. H.
Barnett, L. H.
Bayles, F. P.
Baldwin, D. H.
Binion, Joshua.
Benedikt, V. M.
Bijur, Jos.
Buck, H. W.
Bultman, H. D.
Carter, B. P.
Coykendall, E.
Cox, E. V.
Candler, D. W.
Dobbins, Max.
Durham, H. W.
Dewey, F. H.
Evans, I. N.
Fintel, E. A. von, Jr.
Fletcher, G. W.
Foerster, David.
Fox, M. J.
Gottsberger, B. B.
Gartensteig, Chas.
Grace, F. J. M.
Herzig, C. S.
Huntoon, L. D.
Horton, C. F.
Hadden, H. S.
Jarman, Z. H.
Johnstone, W. B.
Jobbins, F. H.
Janes, E. H.
Kirby, G. T.
Kraemer, H.
Leo, R. L.
Lum, C. H.
McKinlay, W. B.
Miller, S. O.
Moisseieff, L. S.
Moses, P. R.
Moeller, E. J.
Mulliken, H. B.
Natkins, I.
Ormsbee, A. F.
Perrine, Geo.
Peugnet, C. P.
Pinkham, H.
Portuondo, J. M.
Pell, F. L.
Peppmüller, R. H.
Perrin, H. C.
Pilcher, L. F.
Reeve, F. C.
Riker, C. L.
Spaulding, M. B.
Shattuck, L. R.
Shrady, C. D.
Sutton, F.
Stewart, J. H.
Schell, R. M.
Seward, J.
Thomas, E. H.
Tucker, S. A.
Walker, F. W.
Whiting, L.

LIST No. 2.

This list embraces the members of the Alumni Association of the School of Mines under the Constitution of that body. It is urged that all graduates of the School should list themselves under this group. Names not found here are grouped in List No. 3, which includes graduates who are not also members. All graduates are requested to try to make and keep this list correct and accurate.

(REVISED TO APRIL, 1896.)

MEMBERS

OF THE

ALUMNI ASSOCIATION OF THE SCHOOL OF MINES.

A.

ABEEL, GEORGE HOWARD, E. M., ... 1883.
Box 642 Hurley, Iron Co., Wis. Also 5 East 124th St., New York City.

1883–84, Chemist Iron Cliffs Co., Negaunee, Mich. 1885–88, Assistant Manager Cliffs Co., Negaunee, Mich. 1886–1887, Supt. Negaunee Gas Light Co., Mich. 1888–89, Manager Ironton Iron Mining Co., Bessemer, Mich. 1888–89, Agent Pilgrim Mining Co., Bessemer, Mich. 1889, Supervisor Bessemer Township, Gogebic Co., Mich. 1889–92, Agent Ruby Iron Mining Co., Bessemer, Mich. 1888 to 1895, General Manager of Montreal River Iron Mining Co., Hurley, Wis. 1892 to 1894, Vice-President First National Bank, Hurley, Wis. 1892 to date, Vice-President Wisconsin Mining Supply Co., Hurley, Wis. 1893, Vice-President and General Manager Section 33 Iron Mining Co., Hurley, Wis. 1894, Consulting Engineer Newport Mining Co., Supervisor, Town of Vaughn.

ADAMS, RANDOLPH, E. M., ... 1883.
Broken Hill, N. S. Wales, Australia.

1884–87, Assistant Superintendent and Superintendent of the Silver King Mine, Silver King, Arizona. 1887–91, engaged in Australia as Mining Superintendent and Mining Expert, and now Manager of the Central Broken Hill Mine, Broken Hill, N. S. Wales, Australia.

AGRAMONTE, EMILIO, C. E., ... 1886.
110 Lexington Avenue, New York City.
Engineer Department of Public Works.

ALDRIDGE, WALTER HULL, E. M.,. . . . . 1887.
Manager United Smelting and Refining Co., East Helena, Mon.

Beginning July, 1887, Assayer at Colorado Smelting Co., Pueblo. At different times, Chemist of Colorado Smelting Co., Pueblo. August, 1890–91, Assistant Superintendent and Metallurgist of Colorado Smelting Co., Pueblo. Assistant Manager United Smelting and Refining Co. 1893, Manager as above.

ALLEN, CHAS. SUMNER, PH. B., M. D., ... 1874.
Practicing Physician.

ALLEN, ROBERT LAWRENCE, A. M. E. M., . . . 1888.
102 Cambridge Place, Brooklyn, N. Y.

AMY, ERNEST JULIUS HYACINTHE, A. B. E. M., . . 1885.
General Manager, San Juan S. and M Co., Durango, Colo.

1885–86, Chemist and Assayer at works of the San Juan and N. Y. M. and S. Co., at Durango, Colo., with the exception of three months' professional visit to Old Mexico. 1886–87, Assistant Manager of the San Juan and N. Y. M. and S. Co., at Durango Colo. 1887–88, Manager of the Hazelton Mountain Mining Co., at Silverton, Colo. 1888 to April 1, 1890, Assistant Manager of Works of the San Juan Smelting and Mining Co., at Durango, Colo. (the S. J. S. and M. Co. being formed by the consolidation of the S. J. and N. Y. M. and S. Co., of Durango and the Hazelton Mt. Mfg. Co., of Silverton, Colo.) Since April 1, 1890, General Manager of the San Juan Smelting and Mining Co., at Durango, Colo.

ANDREWS, SAMUEL WAKEMAN, JR., PH. B., . . 1890.
Andrews, Waters & Sherwin, 35 W. Forty-second Street, New York City.

1890–91, Designing with Tiffany Glass and Decorating Co., New York. 1891 to date, member of above firm.

ANSBACHER, LOUIS ADOLPH, PH. B., . . . 1892.
A. B. Ansbacher & Co., 4 Murray St. and 24 East 62nd St., New York City.

ANTHON, ARCHIBALD, E. E. (Associate), . . . 1892.
13 West 35th St., New York City.

APPLEBY, W. R., A. B. (Associate), ... 1887.
Professor of Mining and Metallurgy, University of Minnesota, and 911 Fifth St., S. E., Minneapolis, Minnesota; also 29 Bentley Avenue, Jersey City, N. J.

ATHA, HENRY GURNEY, PH. B., ... 1889.
756 High St., Newark, N. J.

AUSTEN, PETER TOWNSEND, PH. B., PH. D., . . . 1872.
Polytechnic Institute, 99 Livingston St., and 876 President St., Brooklyn N. Y.

1878–80, Assistant Professor of Analytical Chemistry, Rutgers College. 1880–1889, Professor of General and Applied Chemistry, Rutgers College. 1891, Superintendent Manufacturies of W. J. Matheson & Co., limited, Ravenswood, N. Y. 1892, General Manager, Ledoux Chemical Laboratory. 1893, Professor of Chemistry, Polytechnic Institute, Brooklyn, N. Y.

AUSTIN, THOMAS SEPTIMUS, E. M., ... 1876.
Chihuahua Mining Co., Chihuahua, Mexico.

1877–78, in Cuba as Chemist. 1879–80, Assayer Germania Smelting Co. 1880–90, Superintendent Rio Grande Smelting Co., Socorro, N. M.

B.

BAKER, GEORGE LEWIS, PH. B., ... 1888.
Address unknown.

BALCH, SAMUEL WEED, E. M., ... 1888.

Box 333, Yonkers N. Y. , and 41 Wall Street, New York City.

1863–84, Otis Elevator Co. 1884–86, Mowing Machines. 1886–89, Garvin Machine Co., Tools and Special Machinery. 1889 to date, General consulting practice as Mechanical Expert and Patent Attorney. Specialty, Difficult Mechanical Problems.

BALDWIN, WILLIAM M., PH. B. (Life Member). . . 1884.

55 Beekman St., New York City, and Garden City, Queens Co., N. Y.

Since 1885, Chemist for the New York Dye Wood Extract and Chemical Co. Since 1888, Vice-President of the above corporation, and at present having charge of their manufacturing department.

BANKS, JOHN HENRY, E. M., ... 1883.

104 John Street, New York City, and Boonton, N. J.

1883–85, Chemist with Ledoux & Ricketts, New York. 1885–91, Private Assistant to Prof. Ricketts, School of Mines, New York, in general analytical, metallurgical and mining engineering work. 1889–91, Hon. Fellow in Assaying, School of Mines. 1894 to date, in partnership with Prof. Ricketts, at above address, in general chemical, metallurgical and mining engineering work, with Ore-testing Works, at Waverly, New Jersey, for determining treatment of ores, and examination of processes.

BARDWELL, ALONZO FRICK, E. M., ... 1883.

Box 773, Aspen, Col.

BARNARD, EDWARD CHESTER, E. M., . . . 1884.

U. S. Geological Survey, Washington, D. C.

Assistant Topographer and at present Topographer in the United States Geological Survey, 1884–91. Have been engaged in mapping in Virginia, West Virginia and the mountains of East Kentucky. 1893, Mapping Northern New York.

BARNETT, L. H., E. M., ... 1894.

289 Columbus Ave., New York City.

BARRATT, EDGAR GRANT, C. E., ... 1884.

1123 The Rookery, Chicago, Ill. and Kenilworth, Ill.

1884–88, Engineer for The Exhaust Ventilator Co. 1888 to date, President and Proprietor of the Exhaust Ventilator Co. 1891 to date, President and General Manager of the Variety Manufacturing Company. Fill the above positions at present and am consulting Ventilating and Heating Engineer.

BARTLETT, FRANK ROOT, C. E., ... 1888.

344 Madison St., Brooklyn, N. Y.

1888 to date, Assistant Engineer Maintenance of Way on Atlanta and Charlotte Division of Richmond and Danville Railroad. From May, 1892, to date, Supervisor of Northwestern North Carolina and North Carolina Midlands Railroads (North Carolina Division of Richmond and Danville Railroads).

BARUS, CARL, PH. D. (Associate), ... 1877.

Brown University, Providence, R. I.

BAXTER, GEORGE STRONG, A. B., E. M., . . . 1868.
17 Broad St., New York City.

1878–79, Civil and Mining Engineer. 1880, Cashier N. P. R. R. 1890, Treasurer N. P. R.R.

BAYLES, FREDERICK, P., E. M. . . . . 1895.
Care Colorado Fuel & Iron Co., Sopris, Colo.

BEARD, JAMES THOM, E. M., C. E., ... 1877.
Box 318, Octumwa Ia.

1879–80, Assistant Engineer, New York and Brooklyn Bridge. 1880–82, Assistant Engineer, C. B. and Q. R.R.; 1882–83, Superintendent Smoky Hollow Mine, Avery, Ia. 1884–85, Assistant U. S. Dept. Min. Surveyor, Aspen, Colo. 1885–91, Engineer, Whitebreast Fuel Co., Ottumwa, Ia.; 1891–92, Manager Miller Creek Land and Lime Co., Aspen, Colo.; 1892–93, Secretary and Treasurer, Eldon Coal and Mining Co., Ottumwa, Ia.; 1893 to date, Iowa Mining Exchange, Ottumwa, Iowa. 1892-94, wrote Beard's *Ventilation of Mines*, published by John Wiley & Sons, New York City.

BECHSTEIN, CHAS. A. . . . . 1888.
495 West End Avenue, New York City.

BEEBE, ALFRED L. PH. B., ... 1880.
Health Department, Criminal Court Building, Centre Street, New York City and 44 Sanfrid Av., Flushing, L. I.

1880–87, inclusive, Private Assistant to Prof Ricketts, School of Mines, New York, in general analytical work, especially Mineral Analyses. Also Assistant in Assaying and Fellow in Chemistry, in 1881–87, inclusive. 1888–92, Assistant Chemist, New York Health Department. Since September, 1892, Bacteriologist, New York Health Department.

BEHRMAN, GEORGE WILLIAM, C. E., ... 1893.
201 Ross Street, Brooklyn, N. Y.

November, 1893, to January 1894, Transitman and Draughtsman, with the Raub Locomotive Works and Land Improvement Company.

BELLINGER, HIRAM PAULDING, C. E., ... 1887.
Solvay Process Company, and 1721 W. Genesee St., Syracuse, N. Y.

BEMIS, FREDERICK POMEROY, A. B., E. M., . . . 1885.
109 West 3d St., Davenport Iowa.

BENEDICT, WILLIAM DE LIESSELINE, E. M., . . . 1874.
Welles Bld'g, No. 18 Broadway, Rooms 617 and 618, New York City, and 282 Vanderbilt Avenue, Brooklyn, N. Y.

1878–80, Assistant Superintendent and Superintendent, Revere Concentrating Co., Utah. 1880–81, Assistant Superintendent, Germania Smelting & Refining Co., Utah. In 1882, opened an office in New York City as Consulting Mining Engineer and Metallurgist, and have since been engaged in examining and reporting on Mines in the United States, Ontario, Quebec, British Columbia, Mexico and England.

BENJAMIN, MARCUS, PH. B., A. M., (Lafayette 1888) (Life Member) 1878, PH. D.

(Univ. Nashville, 1889), Editor, D. Appleton & Co., 72 5th Ave. and 589 West End Ave., New York City.

1878–82, with E. B. Benjamine, dealer in Chemical Apparatus. 1882, Editor *American Pharmacist*. 1883, Editor *Weekly Drug News*, May, 1883, to June, 1885, Chemist, U. S. Laboratory, New York. 1885, Sanitary Engineer, N. Y. Board of Health. 1886–89, Editorial Staff, Appleton's *Cyclopædia of American Biography*. 1890, Editorial Staff, *Engineering and Mining Journal*, chiefly engaged in editing and preparing for the press, George F. Kunz's *Gems and Precious Stones of North America*. 1891–94, Editor of *General Guide to the United States*, *Handbook of Winter Resorts*, and *Handbook of Summer Resorts*, published by D. Appleton & Co. Editorial Staff in charge of Chemistry, Standard Dictionary, 1891, till its completion in 1894. Edited the revised edition *Picturesque America and Art* in 1884, and wrote a booklet entitled, *A Historical Sketch of Madison Square*, during 1894, During 1884–86, Lecturer on Chemistry at New York Women's Medical College and Hospital for Women. At various times on editorial staffs: of *Scientific American*, 1883–89; *Independent Oil Journal*, 1886, and on technical subjects in New York *Daily News*, 1886 to date. New York *Star*, 1890–91, and *Pharmaceutical Record*, 1891, also of Appleton's *Annual Cyclopædia* since 1883. Other work includes translation of Berthelot's lectures on "Explosive Materials," (New York, 1883), authorship of *Druggist's Circular*, Prize Essay on "Disinfectants," authorship of chapters on "Mineral Paints" in *Mineral Resources of the United States*, for years 1884–86, and compilation of a book of Poems, entitled *May Time* (New York, 1889), and authorship of chapter on "Thomas Dongan and the Granting of the New York Charter," 1682–1688, and "The Development of Science in New York City," in *The Memorial History of the City of New York*, 1892. Contributor to *Scientific American* and *Supplement*, *The Chautauquan*, *Harpers Weekly*, *Popular Science Monthly*, *The Cosmopolitan*, etc. Organized the Corresponding Chapters of Chemistry of the Agassiz Association in 1892, and has been its President since that date. Life fellow of the London Chemical Society, and of the American Association for the Advancement of Science, Society of Chemical Industry, London, and American Chemical Society, Member of International Jury of Awards, World's Fair, Chicago, 1893.

BERRY, WILTON GUERNSEY, PH. B., ... 1886.

Health Department, New Criminal Courts Building, New York City.

1886–89, Universities of Berlin and Heidelberg and General Chemical Research 1889 to date, Assistant Chemist, New York Health Department.

BERRY, GEORGE, C. E., ... 1888.

78 Morton St., Brooklyn, N. Y.

BETTS, ROMEO T., C. E., ... 1890.

2789 Atlantic Ave., Brooklyn, N. Y.

BIEN, JOSEPH RUDOLPH, E. M., ... 1887.

Room 308, 189 Montague St. and *for mail* 289 Lewis Ave., Brooklyn, N. Y.

1887–88, Topographer, U. S. Geological Survey, Survey of Geyser Basins, Yellowstone National Park. 1888-90, Practice as Civil and Mining Engineer, firm of Vermeule & Bien, New York City. 1890–91, Practice as Civil and Topographical Engineer alone, New York City. At present, Secretary Julius Bien & Co., Lithographers, Engravers and Geographical Publishers.

BINION, JOSHUA, B. S. . . . . 1895.
C. R. R., of N. J., Jersey City, N. J., and care Miss Freed, 182 E. Broadway, New York City.

Summer of 1893. Volunteer Assistant on New York Speedway. Summer of 1895. Assistant at Summer School of Surveying, Columbia College. October 9, 1895, with C. R. R., of N. J., in charge of Bound Brook depression.

BLACK, ADOLPH, C. E., ... 1894.
1434 Lexington Ave., New York City.

Assistant Instructor Summer School of Surveying Summers, 1893, 1894 and 1895. State Inspector of the N. Y. State Tenement House Committee, 1894. Instructor in Medical Drawing, Y. M. C. A., 23d St. Branch, N. Y. City, 1893 to 1895.

BLAKE, EDWIN MORTIMER, E. M., PH. D. (1893). . 1890
Fellow in Mathematics, Columbia College, New York City, and 230 Washington Ave., Brooklyn, N. Y.

BLEECHER, C. P., ... 1891.
446 Avenue E, Bayone, N. J.

BLOSSOM, FRANCIS, C. E., ... 1891.
Westinghouse Church, Kerr & Co., 26 Cortland St., New York City, and 440 Henry St., Brooklyn, N. Y.

1891–92, Engineer with C. W. Hunt Co. 1892, Assistant Engineer Equity Gas Works Construction Company. 1893, as above.

BLYDENBURGH, CHARLES EDWARD, A. B., A. M., E. M., 1878.
Mining Expert and Prospector, Box 189, Rawlings, Wyoming.

BODELSEN, OSCAR, E. M., ... 1884.
164 W. Sixty-sixth St., New York City.

BŒCKLIN, WERNER, JR., C. E., ... 1891.
Chief Engineer's Office, Penna. Company, Pittsburgh, Pa.

January to May, 1893, ran level on preliminary (150 miles), H. & E. Extension, C. O. & S. W. Railway, in charge of all profiles and estimates under Chief Engineer. 1894, Inspector for Massachusetts Highway Commission on State Highway. Assistant Engineer in charge of erection of Stone Crushing Plant at Rock Hill, N. J.. 1895.

BOGERT, MARSTON T., PH. B., A. B., ... 1894.
259 Broadway, Flushing, Queens County, L. I.

Awarded University Fellowship in Chemistry for 1895, but resigned to accept position of assistant in Organic Chemistry, to which I have been reappointed for present year. In the School of Arts, received the following honors: 1888—German; 1889—German, Spanish and Botany; 1890—German, Spanish, Geology and

Italian. Was one of the three candidates selected by the Faculty as worthy to receive the Alumni Prize "for the most faithful and deserving student of the graduating class." In the election held by the class upon these three names, his name received second largest vote. Chairman of all the undergraduates of the University, at the installation of President Low.

BOOK, DWIGHT DANA, C. E., E. E. (1892), . . . 1890.
159 Washington Park, Brooklyn, N. Y.

BOORÆM, ROBERT ELMER, E. M. (Life Member), . 1878.
2 East 15th St., New York City.

1879, Assayer, general work in Leadville, Colorado. 1880–87, Assistant Superintendent, afterward manager, Evening Star Mining Co., Morning Star Consolidated Mining Co. and others at Leadville, Colorado, Lead-silver Mines. Also in charge Farwall Con. M. Co., Gold Mines at Independence, Colorado. 1887–90, General Manager Blue Bird Mining Co., Ltd., Butte, Montana, Operating 90-Stamp Mill, Dry Crushing, Chloridizing, Amalgamating Process. 1891, General Consulting Mining Engineer and Consulting Director in Gold, Silver and Lead-Mining Companies, of which a Specialty is made. Also Mine Operator and owner, Silver Mines at Aspen, Colorado.

BOYD, RICHARD CHARLES, PH. B., A. M. (1892), , 1891.
44 W. 88th St., New York City.

BRADLEY, STEPHEN ROWE, JR., PH. B., . . . 1890.
392 Broadway, New York City, and Nyack, N. Y.

July, 1891 to 1894, Secretary and Treasurer Union Electric Co. January, 1894. Secretary and Treasurer The Arlington Manufacturing Co., New York City.

BRASCHI, VICTOR MANUEL, PH. B., E. M., C. E., . . 1881.
Apartado 830, City of Mexico, Mex.

June, 1884, to October, 1884, Inspector of New York Tenement House Commission. October, 1884, to May, 1885, Interpreter and Sec'y to Gov. Chilian, Commissioner to Visit and Report on American Mining and Smelting. May, 1885, to October, 1885, Employed by Rend-Rock Powder Co. in Flood Rock Explosion Work. October, 1885, to January, 1889, Assistant Consulting Engineer and in Charge Foreign Business, Rand Drill Co. January, February, March, 1889, Reporting on Mines in Mexico for above Co., and for three years, from April, 1890, to April, 1893, engaged in introducing Rank Rock Drilling Machinery in Mexican Mines. In April, 1893, arranged to open a general Mining Machinery and Supply business, in the City of Mexico, in which I am at present engaged.

BRERETON, THOMAS J. A. B., 1879, C. E., . . . 1883.
Engineer Cumberland Valley Railroad and 5th Ave., Chambersburg, Pa.

1879, Rodman on Location of Redstone Br. P. R. R. 1880 and 1880 (Summers) on New York State Geodetic Survey of Adirondacks. 1883–85, Leveller P. R. R. Clearfield Co. Surveys and Construction. On Corps of Engr. M. of W. P. R. 1888–89, Assistant Supervisor, P. R. R. 1890–92, Supervisor Tyrone Div., P. R. R. 1893, Engineer Cumberland Valley Railway.

BREWSTER, HENRY DRAPES (Associate), . . . 1883.
Care Brewster & Co., 49th St. and Broadway, New York City.

BRINLEY, JOHN ROWLETT, C. E., ... 1884.
Morristown, N. J.

1884–88, Department of Public Works, New York City. 1888 to date, Civil and Sanitary Engineer.

BRITTON, NATHANIEL LORD, E. M., PH. D., . . . 1879.
Columbia College, School of Mines, New York City.

Assistant of Geology, School of Mines, 1879–1887. Instructor in Botany, Columbia College, 1887–1890. Adjunct Professor of Botany, Columbia College, 1890–1891. Assistant, Geological Survey of New Jersey, 1880–1887. Botanist, Geological Survey, of New Jersey, 1881, 1890. Field Assistant, U. S. Geological Survey, 1882. Professor of Botany, 1891. Specialty—Systematic Botany. Sec. New York Botanic Garden.

BROSNAN, FRANCIS XAVIER, C. E. . . . . 1891.
146 W. Seventy-fourth Street, New York City.

BROWN, FRANCIS G., E. M.. . . . . 1867.
Merchant, 15 Whitehall Street and 462 Lexington Avenue, N. Y. City.

BROWNING, JOHN H. BROWER, M. D. (Associate), . . 1883.
Address unknown.

College of Physicians and Surgeons of City of New York, in year 1882. Afterwards Assistant Physician, New York City Insane Asylum, Ward's Island, 1882–83. House Physician and Surgeon to St. Francis Hospital, 1883–85. At date, Member County Medical Society of New York, Member Physicians' Mutual Aid Association, Fellow American Geograghical Society, and Assistant to Chair in Surgery, New York Polyclinic, Medical Examiner for Presbyterian Board of Foreign Missions, General Practitioner of Medicine and Surgery.

BRUGMAN, WILLIAM FREDERIC, PH. B., . . . 1880.
One Hundred and Forty-fourth Street and Southern Boulevard, New York City and Los Angeles, Cal.

BRYCE, WILLIAM, JR., PH. B., ... 1884.
40 W. Fifty-fourth Street, New York City.

BUCKLEY, CHARLES RAMSAY, A. B., A. M., E. M., . . 1877.
29 Broadway, New York City.

BULLMAN, CHARLES, PH. B., ... 1883.
Editor *The Safety Valve*, 55 Liberty Street, New York City, and 808 Third Place, Plainfield, N. J.

1883, Tutor in Stoichiometry, Chemist Putnam Company Chemical Works. 1884–85-86, Venezuela; phosphates, copper, sulphur. 1887, French Guiana; phosphates. 1888, 1889–90, North Carolina, Georgia, Colombia, S. A. (2); gold and platinum. 1891, Sandwich Islands; phosphates. California (2); gold and irrigation. 1892, New Jersey, copper and graphite. 1892–93, Editorial Staff *Engineering and Mining Journal*; also Translator and Editor of *Mining Laws of the*

Republic of Colombia, and Author of *Platinum* and *South America* in "The Mineral Industry."

BURDEN, HENRY 2d, A. B., PH. B., ... 1892.
Cazenovia, N. Y.

BURNS, ABRAHAM LINCOLN, E. M., ... 1887.
3 Worth Street, New York City, and 297 Halsey Street, Brooklyn, N. Y.

Since November, 1887, with Messrs. Jabez Burns & Sons (Millwrights and Machinists, and Manufacturers of Patented Machines for Treating Coffee and Spices). Since July, 1890, in above firm. Professional work has been general shop draughting and machine design, and arranging machines and power transmission in coffee establishments.

BURNS, ELMER Z., E. M., ... 1887.
Niagara Falls, N. Y.

1887–88, Engineer and Chemist for the Pittsburgh and Lake Angeline Iron Co. 1889–90, Assistant Electrician for the United States Electric Light Company. 1890–91, Assistant Electrician for the Mather Electric Company. 1891–93, City Engineer of Niagara Falls, and Consulting Engineer for the Lewiston and Youngstown R. R. Company, for the North Tonawanda Street Railroad Company, and for the Niagara Falls and Suspension Bridge Railroad Company.

BURRITT, WILMOT WOODWARD, PH. B., . . . 1884.
Chemist, Englewood, N. J.

BUSH, EDWARD RENSHAW, E. M., ... 1881.
Mining Engineer, with Ricketts & Banks, 104 John St., New York City.

BUTLER, NATHANIEL, E. M., ... 1880.
51 Cedar St., Room 7, New York City, and Glen Ridge, Bloomfield, Essex Co., N. J.

1880–82, U. S. Harbor Improvement and Railroad Engineering. 1882–94, Barlow's Insurance Surveys as Surveyor, Superintendent and Executive.

BUTLER, WILLIAM CURTIS, MET. E., ... 1887.
Everett, Washington, and 165 Hamilton Ave., Paterson, N. J.

1887–89, Assayer, El Paso Smelting Co., El Paso, Texas. 1889–90, Chemist, afterward Assistant Superintendent, Arkansas Valley Smelting Co., Leadville, Colo. 1890, Chemist, now Assistant Manager, Aurora Iron Mining Co., Superior Mining Co., Comet Mining Co., Palone Iron Mining Co., Penokee and Gogebic Development Co. (Operating Colby and Tilden Mines). Also in charge Ironwood Electric Co., Gobebic Electric Co. 1892, Superintendent Monte Cristo Mining Co., Seattle, Washington. 1893, Manager Puget Sound Reduction Co. 1894, President and Treasurer Puget Sound Reduction Co.

BUTLER, WILLARD PARKER, E. M., LL. B. (Life Member), 1878.
Counsel in Patent Causes, 59 Wall St. and 137 E. 39th St., New York City.

C.

CADY, LINUS BERTRAM, E. M., C. E., ... 1877.
327 Fifth Ave., New York City.

CALMAN, ALBERT, PH. B., PH. D., ... 1882.
7 W. 75th St., New York City.

CANFIELD, AUGUSTUS CASS, E. M., ... 1877.
Address unknown.

CANFIELD, FREDERICK A., A. B., A. M., E. M., . . 1873.
Mining Engineer, Dover, N. J.

CARSON, JAMES PETIGRU, E. M., ... 1868.
16 Exchange Place, New York City, and Dean Hill Oakly, P. O. S. Ca.

CARTER, B. P., E. M., ... 1895.
Crown Deep Mine Ltd., P. O. Box 771 Johannesburg, S. A. R.

CASAMAJOR, GEORGE H., C. E., ... 1892.
372 Green Ave., Brooklyn, N. Y.

CASEY, EDWARD PEARCE, C. E., PH. B. (1888), . . 1886.
Architect, 171 Broadway and The Alpine, 55 West Thirty-third St., New York City.

With McKim, Mead & White, Architects, New York City, until January, 1890. Abroad, and Student in L'Ecolo National des Beaux Arts, Paris, from February, 1890, until September, 1893. Five mentions in Architecture, and a medal in Modeling. At present Architect, 171 Broadway, New York City.

CAULDWELL, JOHN BRITTON, C. E., ... 1877.
Century Club, 7 West Forty-third St., New York City.

CHANNING, JOHN PARKE, E. M., ... 1883.
34 Park Place, New York City.

1883, Chemist Hudson River, O. and I. Co. 1884, with S. E. Cleaves & Son, Manufacturers of Mining Machinery, Houghton, Mich. 1884-85, Assistant Mining Engineer Tamarack Mine, Calumet, Mich., Dep. Comm. Mineral Statistics, Michigan. 1885-86, Superintendent Honduras Land and Navigation Co. 1886-87, Exploring for iron on the Gogebic Range, and Mining Engineer for Milwaukee, L. S. and Western Railway, Superintendent Iron Belt Mine. 1887-90, Inspector of Mines, Gogebic Co., Mich. 1890-92, Superintendent East New York Iron Co., Ishpeming, Mich. 1892 to 1893, Superintendent Iron Exploration C., M. and St. P. Railway. Assistant to General Manager Calumet and Hecla Mining Company, 1894, Consulting Work, 1894, to date.

CHAZAL, PHILIP EDWARD, A. B., E. M., . . . 1881.
68 Meeting Street, Charleston, S. C.

1881-83, Prospecting in Northwest Georgia. 1883-89, State Chemist of South Carolina. 1889 to present, Partner in Shepard Laboratory, specialties Phosphate and Fertilizer Analysis and examination and reporting on Phosphate lands in (in South Carolina and Florida).

CHESTER, ALBERT HUNTINGTON, A. M., E. M., SC. D., PH D., 1868.
Professor of Chemistry and Mineralogy, Rutgers College, and 35 College Avenue, New Brunswick, N. J.

Professor of Chemistry at Hamilton College from 1870 and Mineralogy from 1878 to 1891. Conducted the Analytical Laboratory there from 1871. Chemist New York State Board of Health, 1882. Examined and reported on Mines of iron, gold, silver, lead and zinc, in Michigan, Minnesota, Ontario, Arkansas, Colorado, Utah, Nevada, California, and Nova Scotia. Analytical work has been largely in two lines, viz., for iron-blast furnaces and of paints and varnishes. Field work has been, a great part of it, in the iron mines of Minnesota and the gold mines of Colorado. Now engaged in chemical work for the State Geological Survey of New Jersey.

CHURCH, ELIHU DWIGHT JR., E. M., ... 1887.
Church & Co., Trenton, Wayne County, Mich.

1887–88, Fellow Qualitative Analysis School of Mines. 1888–89, Assistant Superintendent of Lead Mine and Concentrating Works. 1889–91, with Church & Co., in charge of experimental plant.

CHURCH, JOHN ADAMS, A. M., E. M., PH. D., . . 1867.
Corn Exchange Building, 11 William Street, and 1350 Madison Avenue, New York City, Cable address Scotist, N. Y.

CLARK, DIEGO LOMBILLO, C. E., ... 1890.
Cardenas, Cuba.

CLARK, EDMUND (Associate), ... 1892.
Health Dept., Criminal Court Bldg., Centre and Franklin Streets and 178 West 97th Street, New York City.

From August, 1892, to August, 1895, Assistant Chemist, Homestead Steel Works, Carnegie Steel Co., Pittsburg, Pa. Since August 1, 1895, Assistant Chemist, Board of Health. New York City.

CLARK, EDWIN PERRY, E. M., ... 1880.
Title Guarantee and Trust Co., 26 Court Street, and 464 Second Street, Brooklyn, N. Y.

1880–83, Engineer and Surveyor for Silver-Cord Combination, and Robert E. Lee Mining Companies, Leadville, Colo. 1883–84. Medical student. 1884 to date, Assistant Superintendent and afterwards Superintendent Title Guarantee and Trust Company, 55 Liberty Street, New York, and 26 Court Street, Brooklyn. In charge of construction and maintenance of locality-indexes of Real Estate Records of New York, Kings and Westchester counties, N. Y.

CLARK, FRANKLIN SINCLAIR, E. M., PH, D., . . . 1885.
Carolina Oil and Creosote Co., Wilmington, N. C. and 527 Madison Avenue, New York City.

1885–87, Chemist to Fernoline Chemical Co., Charleston, S. C. 1887 to date, Proprietor of Southern Chemical Works and consulting chemist for the Carolina Oil and Creosote Co., Wilmington, N. C. Specialty, Distillation of Wood and refining products and creosoting wood.

CLARK, WILLIAM C., M. E., ... 1892.
Sterlington, Rockland Co., N. Y.

CLARK, GEORGE HALLETT, C. E., ... 1893
Lex. Ave. and P. Ferry R. R. Co., 621 Broadway, Room 840, and 59 E. Sixty-seventh St., New York City.

1893-94, Transitman Metropolitan Traction Co., Lexington Ave. Cable Construction. Assistant Engineer in Charge construction Lexington Avenue Cable Road.

COKEFAIR, FRANCIS A., C. E., ... 1894.
66 Broadway, New York City, and 119 Cresent Ave., Plainfield, N. J.

COLBY, ALBERT LADD, PH. B., ... 1881.
The Bethelem Iron Co., South Bethelem, Pa.

1881-83, Assistant to Prof. C. F. Chandler on New York State Board of Health Bureau of Chemical Analysts. 1883-86, Instructor in Quantitative analysis and Chemical Philosophy in the Lehigh University, South Bethlehem, Pa. 1886-92, Head Chemist of the Bethlehem Iron Co. 1893 to date, Metallurgical Engineer same Company, South Bethlehem, Pa. Specialty, Metallurgy of Iron and Steel.

COLBY, CHARLES EDWARDS, E. M., C. E., . . . 1877
Adj. Professor Organic Chemistry, Columbia College School of Mines, New York City.

COLE, HAROLD MORRIS, E. M., C. E., ... 1887.
Care United S. and R. Co., East Helena, and 1045 N. Warren St., Helena, Montana.

COLTON, CHARLES ADAMS, E. M., ... 1873.
21 Park St. and 57 Broad St., Newark, N. J.

1873-82, Assistant in Mineralogy, School of Mines, Columbia College, New York. 1882-84, Professor of Chemistry and Mineralogy, Rose Polytechnic Institute, Terre Haute, Indiana. 1884 to date, Director and Instructor in Chemistry and Physics, Newark Technical School.

CONANT, HENRY DUNNING, E. M., ... 1886.
Care Messrs. Gaminara & Leeder, Tumaco, Republic Colombia, S. A.

1886-88, Assistant Engineer Tamarack and Osceola Mines, Lake Superior, and H. and C. RR. 88-1889, Assistant Engineer on Preliminary of Northern Michigan Railroad. 1889, Assistant in Chief Engineer's Office, Buffalo and Geneva Railway. 1889-91, Assistant and Resident Engineer Norfolk and Western Railroad, in charge of Preliminary Location and Construction. 1891, Engineer Coeburn Land and Improvement Co. 1893, Assistant Engineer N. Y., N. H. & H. Ry. 1894, Assistant Engineer Plaza de Oro Mining Co., Ecuador, S. A.

CONGDON, ERNEST ARNOLD, PH. B., F. C. S., . . 1887.
Professor of Chemistry, Drexel Institute Arts, Science and Industry, and 1336 Spruce Street, Philadelphia, Pa., or care H. M. Congdon, 18 Broadway, New York City.

1887–89, Chemist to Champlain Fibre Co., Willsborough, New York. 1889, Studied at the University of Berlin, Summer Semester. 1889 to date, Instructor in Qualitative Analysis and Assaying at the Lehigh University. 1891, Professor of Chemistry in the Drexel Institute of Arts, Sciences and Industries, Philadelphia, Pa.

COOPER, WILLIAM HAMILTON, PH. B. (Life Member), . 1882.
Address unknown.

CORCORAN, JOHN THOMAS, E. M., S. E., . . . 1884.
131 Smith Street, Brooklyn, N. Y.

CORNELL, GEORGE BIRDSALL, E. M., C. E., . . . 1877.
29 Broadway and 46 West Forty-eight Street, New York City.

Assistant Engineer Manhattan Elevated Railway. Engineer for Contractors for structure Manhattan Elevated Railway. Assistant Engineer Brooklyn Elevated Railway. Assistant Engineer New York, Chicago and St. Louis R. R. Principal Assistant Engineer Rochester and Pittsburgh Railway Inspector and Engineer Bridge Department N. Y., West Shore and Buffalo Railway. Principal Assistant Engineer Brooklyn Elevated Railway. Chief Engineer Brooklyn Elevated Railway. Chief Engineer Union Elevated Railway, of Brooklyn. Chief Engineer Chicago and South-side Elevated Railway. Chief Engineer J. B. & J. M. Cornell Iron Works. At present Chief Engineer East River Bridge Company.

CORNWALL, HENRY BEDINGER, A. B., A. M., E. M., PH. D., 1867.
Professor Analytical Chemistry and Mineralogy, College of New Jersey, and 51 Nassau St., Princeton, N. J.

CORNWALL, HARRY CLAY, E. M., ... 1879.
Commonwealth Insurance Co., Nassau Street, New York City.

COX, JENNINGS STOCKTON, JR., MET. ENG., . . . 1887.
902 Lewis Block, Pittsburgh, Pa.

1887, Government Survey for Canal between Harlem and Hudson River. 1888–1889, Homestead Steel Works, Draughtsman and afterward Assistant Master Mechanic. 1890, Inspected construction of Steamer "Sezurania" and "Vigilancia" for the U. S. and B. M. S. S. Co., at Roach's Shipyard, Chester, Pa. 1891, Reporter for same Company on Engineering matters along the Brazil coast. 1892, with same Company in New York. 1892, Assistant Superintendent Aurora Iron-Mining Company, Ironwood, Michigan. 1893. Assistant Superintendent Monte Cristo Mining Co., Pride of the Mountain Mining Co., Rainy Mining Co., and United Concentration Company.

COYKENDALL, EDWARD, C. E., ... 1895.
Rondout, N. Y.

CRAMER, STUART W., E. M. (Associate), . . . 1889.
Manager The D. A. Tompkins Co., Charlotte, N. C.

Graduate of United States Naval Academy; resigned from the United States Navy, September, 1888. Graduate student at School of Mines, 1888–89. Assayer in charge of the United States Assay Office, Charlotte, N. C., 1889–93.

Special agent for collection of statistics on gold and silver for the Southern States, 1890. March 10, 1893, to present time, Engineer and Chemist for the D. A. Tompkins Company, General Engineers and Contractors, of Charlotte, N. C. Special correspondent of *Engineering and Mining Journal*. Specialty: Westinghouse system of electric lighting and transmisson of power.

CROCKER, FRANCIS BACON, E. M., ... 1882.
Professor Electrical Engineering, Columbia College School of Mines, and 110 West 39th Street, New York City.

1882–86, Electrical Engineer and Inventor. 1886–87, Vice-President and Electrician of "C. and C." Electric Motor Co. 1887–89, Vice-President and Electrician Crocker-Wheeler Electric Motor Co. 1889–92, Instructor in Electrical Engineering, School of Mines, Columbia College. 1892, Adj. Professor. 1893, Professor.

CUSHMAN, ALEXANDER RAMSAY, PH. B., PH. D., . . 1878.
Assistant Analytical Chemistry, Columbia College School of Mines, and 128 E. Sixteenth Street, New York City.

1878–80, Post Graduate study at the School of Mines, for degree of Ph. D. 1880–82, in Colorado, visiting mines and smelters. 1882–90, Engaged in pursuing chemical studies and lecturing on geology. 1890 to date, Assistant Instructor in Qualitative Laboratory at the School of Mines, Columbia College.

D

DARWIN, HARRY GILBERT, C. E., ... 1887.
Room 23, 160 Broadway, New York City, and Glen Ridge, N. J.

June, 1887, to October, 1887, Rodman and Leveller on Railroad field work in New York State. October, 1887, to May, 1888, Draughtsman Strong Locomotive Co., New York City. August, 1888, to date, Assistant Engineer and Acting Superintendent Safety Car Heating and Lighting Co., New York City. Erection of special gas works, and equipment of railroad cars, etc. P. Asst. Eng. S. C. H. L. Co.

DAVIS, CHARLES HENRY, C. E., ... 1887.
Room 306 Fidelity and Casualty Building, 99 Cedar Street and 576 Lexington Avenue, New York City.

Expert Course and Thompson-Houston Electric Co., Lynn, Mass., summer 1887. Agent, Lawyer Mann Electric Co., winter 1887–88. Supt. selling and construction New York office S. M. Elec. Co., summer and winter 1888. Agent Westinghouse Electric Company, winter 1889. Consulting and Supervising Electrical Engineer from May, 1889, to date.

DAVIS, JOHN WOODBRIDGE, C. E., PH. D., . . . 1878.
Principal Woodbridge School, 417 Madison Avenue and 25 West 119th Street, New York City.

DEGHUÉE, JOSEPH ALBERT, PH. B., A. M., (1892) PH. D., (1893) . . . . . 1890.
Chemical Laboratory College Phys. and Surg., New York City, and 247 Harrison St., Brooklyn, N. Y.

Assistant Demonstrator in Physics and Chemistry, College of Physics and Surgery.

DELAFIELD, AUGUSTUS FLOYD, PH. D. (Associate), . 1869.
University Club, New York City.

DELUZE, LOUIS PHILIPPE, C. E., ... 1879.
DeLuze & Emmett, Engineers and Surveyors, New Rochelle, N. Y.

DENTON, FREDERICK WARNER, C. E., ... 1884.
University of Minn. and 1100 5th St., Minneapolis, Minn.

1889–90, Fellow in Engineering, School of Mines. 1890–94, Professor of Mining and Civil Engineering, Michigan Mining School, and in general practice of engineering. 1894 to date, Mining Engineer Minnesota Iron Co. Secretary of the Lake Superior Mining Institute since its organization in 1893.

DEVEREUX, WALTER BOURCHIER, A. B., A. M., E. M., 1878.
Sherman Square Hotel, New York City.

DOBBINS, MAX, E. M., ... 1895.
Care of Lehigh Valley Coal Co., Engineering Department, and 14 Wright St., Wilkesbarre, Pa.

DODGE, FRANK DESPARD, PH. B., PH. D., . . . 1888.
Dodge & Olcott, 137 Water St. and 111 Montague St., Brooklyn, N. Y.

From October, 1891, to date, Chemist, with Dodge & Olcott, manufacturers of essential oils, etc. 1888–90, Fellow in Chemistry, Assistant in Organic Laboratory School of Mines. 1890–91 (studying in Germany).

DODSWORTH, WALTER ALBERT, PH. B., . . . 1888.
19 Beaver St., New York City, and 253 Henry Street, Brooklyn, N. Y.

With Journal of Commerce and Commercial Bulletin.

DOLAN, CHARLES FRANCIS, C. E., ... 1892.
111 East 129th St., New York City.

1892-93, United States Inspector of Dredging Operations, Harlem Ship Canal and Newtown Creek. 1893 to date, with Department of Street Improvements, New York City. 1894, With U. S. Engineers on New York Harbor Improvements.

DONNELL, HARRY ELLINGWOOD, PH. B., . - . 1887.
Address unknown.

DOUGLAS, JOHN SHEAFE, C. E., . . - . . 1890.
Chaplin-Douglass Electric Co. Mnfgs. Agents, 136 Liberty St., and 72½ Irving Place, New York City.

1890, Course Electrical Engineering, Columbia College. 1891, Crocker-Wheeler Electric Motor Company, and now Assistant Engineer Western Electric Company in Lighting Department. 1893, Superintendent of Union Elect. Co.'s Exhibit at World's Columbian Exposition, Chicago.

1895, Secretary and Treasurer Chapin-Douglas Elec. Co.

DOUGLASS, EDWARD MOREHOUSE, C. E., . . . 1881.
Topographer U. S. Geol. Survey, and Takoma Park, Washington, D. C.

DOW, ALLAN WADE, PH. B. (Life Member), . . 1888.
Office of the Engineer Commission, District of Columbia, Washington, D. C.

1888–89, Honorary Fellow Quant. Laboratory, School of Mines. 1889, Chemist at Tilly Foster Mine, New York. 1889-91, Assistant Chemist of The Barber Asphalt Paving Co. 1894, District Chemist, Inspector Asphalt Cement and Building Stone, District of Columbia.

DOWNS, WILLIAM FLETCHER, E. M., ... 1882.
Joseph Dixon Crucible Co., and 75 Fairview Ave., Jersey City, N. J.

With the Joseph Dixon Crucible Co. since graduation. From June, 1882, to September, 1882, at experimental work. From September, 1882, to October, 1884, in charge of lubricating department. From October, 1884, to present time Superintendent of crucible and other departments.

DRESSER, DANIEL LE ROY, C. E., ... 1889.
Oyster Bay, L. I., N. Y.

DRUMMOND, ISAAC WYMAN, E. M., PH. D., . . . 1878.
F. W. Devoe & Co., William and Fulton Sts., New York City.

DUFOURCQ, EDWARD LEONCE, E. M., ... 1892.
San Miguel de Mesquital, Catalina, Durango, Mexico, and 846 Lexington Ave., New York City.

1892–93, Assistant Superintendent Costa Rica Pacific Gold Mining Company, Punta Arenas, Costa Rica. Summer of 1893, Assistant in Mining, Columbia College and Transitman for J. F. Carey & Co., Brooklyn. November, 1893, Assistant Engineer, Mazapil Copper Company, Concepcion del Oro, Zacatecas, Mexico, and Assistant Engineer Coahuila and Zacatecas Railroad. Fall of 1894, Engineer of International Mining Co., San Miguel de Mesquital, Mexico.

DUNHAM, EDWARD KELLOGG, PH. B., ... 1881.
338 East Twenty-sixth Street, and 110 W. 57th St., New York City.

Professor of Pathology, Bacteriology and Hygiene in the Bellevue Hospital Medical College, New York City.

DURHAM, H. W., C. E., ... 1895.
125 Brooklyn Avenue, Brooklyn, N. Y.

Draughtsman Rapid Transit Commission, June to December, 1895.

DUSENBERRY, WALTER LORTON, E. E., . . . 1884.
220 Tenth Street, S. Brooklyn, N. Y.

1884–87, miscellaneous. U. S. Coast Survey. Mining in Mexico and the west. Survey of New Parks, Westchester County, etc. 1887–89, Inspector of Masonry and Transitman on New Croton Aqueduct. 1889-91, in charge of party and Assistant Engineer of Construction Department of Public Parks, New York City.

DUTCHER, BASIL H., PH. B., ... 1892.
525 Manhattan Avenue, New York City.

Summer of 1890, on Reconnaissance Survey in Idaho and Nevada, Biological Survey, U. S. Department of Agriculture. Summer of 1891, on Death Valley Survey, California, U. S. Department of Agriculture. Summer of 1892, Biological Survey, U. S. Department of Agriculture, in Kansas, Oklahoma, Texas, New Mexico. Winters, 1892-93 and 1893-94, Student College Physicians and Surgeons, Columbia College.

DWIGHT, ARTHUR SMITH, E. M., ... 1885.
Superintendent Colorado Smelting Co., Pueblo, Colorado.

1885, Assistant Assayer at works of The Colorado Smelting Company, Pueblo, Colorado. 1885 to 1888, Assistant Chemist and Chemist, except autumn of 1886, when examining and reporting on lead deposits of Cœur d'Alene region, Idaho Territory, and spring of 1889, when acting as Assistant Supt. Madonna Mine, Monarch, Colo. 1889-90, Metallurgist, and 1890 to date, General Supt. of the Colorado Smelting Co.

E.

EASTON, LANGDON CHEVES, C. E., ... 1884.
Port Hartford, San Luis Obispo, Co., and 344 South Grand Avenue, Los Angeles, Cal.

1885-88, Engineer Corps, Aqueduct Commission, New York City. 1889, City Surveyor's Corps, Los Angeles, Cal. 1889 and 1891, in charge of harbor improvements, Port Harford, Cal., under direction of U. S. Corps of Engineers.

EASTWICK, GEORGE SPENCER, C. E., ... 1879.
Manager American Sugar Refining Co., 24 North Peters St., New Orleans, La., and 1425 Broadway New York City.

EASTWICK, EDWARD PEERS, JR., PH. B., S. E., C. E., (1892), 1889.
Care of American Sugar Refining Company, New Orleans, La.

EBERHARDT, WILLIAM G., E. M., ... 1891.
450 W. Twenty-second St., New York City.

1891-93, General Engineering and Draughting, March, 1893, to May, 1894, Assistant Superintendent and Assayer Powhatan Lead and Mining Co., Va. At present Assayer and Surveyor Mazapil Copper Co., Concepcion del Oro, Zacatecas, Mexico.

EDDIE, EDWARD CRITTENDEN, E. M., ... 1885.
Colorado Smelting Co., Pueblo, Colo.

EDWARDS, RICHARD MASON, E. M., ... 1886.
Red Jacket and Houghton, Mich.

1886-87, General Assay office at Houghton, Mich. 1888-89, Professor of Mining, Michigan Mining School, Houghton. 1890 to date, Mining Engineer for Tamarack, Tamarack, Jr., Osceola and Kearsarge Mining Cos., L. S. Mich.

EILERS, KARL EMRICH, E, M., ... 1889.
Assistant Superintendent Colorado Smelting Co., Pueblo, Col., and 751 St. Mark's Ave., Brooklyn, N. Y.
1889–91, student and traveling in Europe.

ELLIOTT, ARTHUR HENRY, PH. B., PH. D., . . . 1881.
4 Irving Place, N. Y. City, and Peekskill, N. Y.
Professor Chemistry and Physics, New York College of Pharmacy. Chemist to Consolidated Gas Co. Editor Anthony's *Photographic Bulletin*. Author A. H. Elliott's Qualitative Chemical Analysis.

ELLIOTT, WILLIAM, PH. B., ... 1880.
56 Wall St., New York City.

ENGEL, LOUIS GEORGE, E. M., ... 1880.
Brooklyn Sugar Refinery, American Sugar Refinery Co., Kent Ave., and S. 2d St., and 238 Clermont Ave., Brooklyn, N. Y.
Three years, Tilly Foster Iron Mine (E. M.). Ten years, Brooklyn Sugar Refinery.

ENGELHARDT, EUGENE NICHOLAS, E. M., . . . 1885.
Selby, Contra Costa Co., Cal.
1886, Assayer, Chemist and Assistant Superintendent Pueblo Smelting and Refining Co. 1887 and 1888, Superintendent of the same company. 1889, Assistant Superintendent Anaconda Smelting Co. From 1890 and to present time, Assistant Superintendent Selby Smelting and Lead Co.

EVANS, I. N., C. E., ... 1895.
41 Day St., New York City.

F.

FAHYS, GEORGE ERNEST, C. E., ... 1884.
38 Maiden Lane, New York City, and 285 DeKalb Ave., Brooklyn, N. Y.
Treasurer, Prentiss Calendar Time Co.

FALK, DAVID BEAUREGARD, C. E., ... 1882.
Savannah, Ga.

FEARN, PERCY LE ROY, E. M., ... 1889.
18 Broadway, New York,
1889–90, Assayer and Surveyor, Trinidad Mine, Costa Rica. 1890–92, Superintendent,, Trinidad Mine, Costa Rica. 1892–93, Consulting Mining Engineer Illinois Fluor Spar and Lead Co. With Olcott, Fearn and Peele, 18 Broadway, New York.

FERGUSON, WILLIAM CUSHMAN AUGUSTINE, PH. B., . 1887.
Nichols Chemical Co., Laurel Hill Chemical Works, Laurel Hill, N. Y, and 40 N. Parsons Ave., Flushing, L. I., N. Y.
Chief Chemist, Nichols Chemical Co., Laurel Hill, N. Y.

FERRER, CARLOS FERRER, C. E., ... 1883.
39 Broad Street, New York City.

After graduation for a few weeks on work at the School of Mines. Then under Mr. W. E. Worthen, C.E., on some work for the Water Commissioners of the State of New Jersey. From March, 1884, to January, 1887, on the Engineering Corps of the Aqueduct Commissioners, New York City, as Assistant to Engineer of Construction ; Leveler in charge of field work on Section "A ;" reduced to Rodman in charge of same; promoted to Assistant Engineer; resigned in January, 1887, and have since been engaged in business for my own account at above address.

FERRIS, JUNIUS COLTON, E. M., ... 1883.
Carthage, Ill.

FEUCHTWANGER, HENRY, PH. B., ... 1882.
Room 19, 99 Franklin St., New York City.

FIALLOS, ENRIQUE, CONSTANTINO, C. E., . . . 1883.
No. 27, Calle 10a, Tegucigalpa, Honduras, C. A., and care Ernest Schernikow, P. O. Box 3540, New York City.

General practice in Engineering. Professor of Mathematics and Mineralogy in the University of Tegucigalpa. The most extensive practice has been as Government Surveyor of Lands and Mines.

FISHER, WILLARD, E. M., ... 1888.
Agent Illinois Zinc Co., 115 Broadway, and 361 W. Fifty-sixth St. New York City.

Draughtsman to Parsons, C.E., New York City. Assistant to Superintendent Segovia Gold Mining Co., Nicaragua. Clerk, Office of Rich Hill Coal Mining Co., Rich Hill, Mo. Engineer and Mine Surveyor, Rich Hill Coal Mining Co., Rich Hill, Mo. Prospecting for coal, Southwest Missouri, along the line of Wichlaw & Western in the interest of the Missouri Pacific Railroad. Southern Sales Agent, Coal Cos., on the lines of Missouri Pacific Railway. President Tyler S. E. Railway of Texas.

FLOYD, FREDERICK WILLIAM, C. E., M. E., . . . 1877.
529 W. Twentieth St., and 175 W. Eighty-seventh St. N. Y. City.

1877–78, Honorary Assistant in Metallurgy, School of Mines. 1878 81, U. S. Geographical Surveys, West of 100th Meridian. 1881-82, Preliminary Surveys, New Croton Aqueduct and Dam. New York. 1882, Reporting on Mines in Colorado. 1883 to date, Firm of James R. Floyd & Sons, Iron Works. Specialty, Gas Engineering and Gas Works Construction.

FOERSTER, DAVID, E. M., ... 1895.
Box 4, Woodland Park, Colo., also 5 East Pearl Street, Cincinnati, O.

Chemist, N. J., Zinc and Iron Co. Assayer and Surveyor, Nut Creek, Colo.

FOLGER, EDWARD P., ... 1894.
80 Quincy Street, Brooklyn N. Y.

FOSTER, REGINALD GUY, C. E., ... 1893.
16 E. Thirty-first Street, New York City.

FOWLER, ALBERT CASIMIR, C. E., ... 1889.
Cienfuegos, Cuba.

FOWLER, SAMUEL STEWART, A. B., E. M., . . . 1884.
Golden, British Columbia, Canada, and Room 201, 34 Clark Street, Chicago, Ill.

1885, Civil Engineering Work, New York. 1886, Assistant Superintendent, Iron Hill Mining and Milling Co., Black Hills, South Dakota. 1887, Assistant Superintendent Galena Reduction Co., Black Hills, South Dakota. 1888, Superintendent, International Smelting Works, Texas. Engineer and Assayer, Bunker Hill and Sullivan Mg. and Conc. Co., Idaho. 1889, Reporting sundry properties. 1890 to date, Superintendent Golden Mining and Smelting Co., Golden, B. C., Canada. Deputy Commissioner World's Columbian Exposition, 1893.

FOYE, ANDREW ERNEST, C. E., ... 1890.
Instructor in Civil Engineering, School of Mines, Columbia College, and 163 West Seventy-ninth Street, New York City.

1890-92, Engineer's office, M. W. P. R. R. 1892-94, Tutor in Civil Engineering, School of Mines. 1894, Instructor in same.

FRANK JEROME WILLIAM, PH. B., ... 1888.
29 Broadway, New York City.

FREEDMAN, WILLIAM HORATIO, C. E., ... 1889.
27 Thames Street and 157 W. 119th Street, New York City.

Post-graduate in Elect. Engineering, 1889-91. John Tyndall Fellow, 1891-92. Tutor in Elect. Engineering, since 1892. Additional degree of E. E., in June, 1891. Associate Editor *Electric Power*.

FRIEDMAN, SAMUEL, C. E., ... 1892.
Tuscaloosa, Ala.

FURMAN, HOWARD VAN FLEET, E. M., ... 1881.
Room 118 Boston Building, Denver, Col.

1882-88, Assayer and Chemist and Foreman, Germania Lead Works, Utah. Chemist, Globe Smelting and Refining Co., Denver. Assistant Superintendent, Billings Smelter, Socorro, New Mexico. Superintendent, Bailey Smelter, Denver, Colo. 1888 to 1894, Consulting Mining Engineer and Metallurgist, Office in Denver. 1894 and 1895, Chief Assayer U. S. Mint, Denver, Colo. 1896, Professor of Mining and Metallurgy, Colorado State School of Mines, Golden, Colo., also office as above.

G.

GARLICHS, HERMAN, E. M., ... 1880.
Care of Cons. K. C. S. & R. Co., Argentine, Kansas.

1880-83, Surveying and Reporting on Mines in Colorado. 1883-87, Assistant Superintendent, Aurora S. & R. Co., Aurora, Ill. 1887 to 1894, Superintendent Refining Department, Omaha and Grant S. and R. Co. Specialty, Silver and Lead Smelting and Refining. 1894, Metallurgist, Velardena Mining Co. Superintendent Refining Department. Cons. K. C. S. & R. Co. Oct. 1, 1895 to date.

GILDERSLEEVE, A. C., C. E., ... 1895.
28 W. 48th St., New York City.

GIFFORD, STANLEY DEVOL, E. M., ... 1889.
Butte City, Montana, and Tuckahoe, N. Y.
Vice-President, Montana Ore Purchasing Co.—Eagle Pass, Mexico.

GILLETTE, HALBERT POWERS, ... 1892.
Care State Engineer, Albany, N. Y.
1892-94, Deputy County Surveyor on highways and bridges; 1894-95, Boat Railway Survey, Dalles, Ore., contractor and designer for highway bridges; 1895, Asst. Summer School of Surveying. School of Mines. Asst. Dept. Physics, 1895. Asst. to State Engineer, N. Y., on Canal Improvements.

GOING, CHARLES BUXTON, PH. B., ... 1882.
President Cincinnati Desiccating Co., Cincinnati, and Glendale, O.
Trustee and Secretary and Treasurer, Glendale Water Works, 1892-95.

GOLDSCHMIDT, SAMUEL ANTHONY, A. B., A. M., E. M., PH. D. (Life Member), ... 1871.
Treasurer Columbia Chemical Works, 43 Sedgwick St., Brooklyn, N. Y., and New York City.
Assistant Ohio Geological Survey, 1871. Chemist and Assistant Inspector of Fertilizers, Savannah, Ga., during winters of 1871-75. During summers, Assistant to Dr. Chandler, Inspector New York Board of Health, 1873-75. Reporting on Guano Islands, South Pacific, 1876. General Consulting Practice, 1876-80. Inspector Offensive Trades, New York Board of Health, 1879-88. Treasurer and Manager Columbia Chemical Works, 1880 to date. Specialty, Ammonia Manufacture.

GOOD, GEORGE MCCLELLAND HOUTZ, E. M., . . 1886.
Mining Engineer, Osceola Mills, Clearfield Co., Pa.
1887-91, Engineer to the Houtz Estate, Houtzdale, Pa. 1892, Mining Engineer to the United Collieries Company. 1892, Assistant General Manager of the same. Also in 1895, Assistant Engineer Altoona & Philipsburg connecting R. R. July 1895, Chief Engineer of same.

GOODWIN, EDWARD, E. M., ... 1891.
Moscow, Idaho.
July, 1887-October, 1889, on Harlem River Canal, New York. 1891, Assistant in Minerology, and to spring of 1893, Assayer for Tombstone Mill & Mining Co., Tombstone, A. T. Spring of 1893, Experimental Cyanide plant at Tombstone A. T. Fall of 1893-summer 1894, Assayer at Texas Con. Gold Mine, and Assayer and Assistant Superintendent at Bully Choop Mines, Shasta Co., California. December 1894-June 1895, Assayer, Puget Sound, Red Co., Everett, Wash. June 1895-October 1895, Assayer and Foreman, Monto Cristo Mining Co., Monto Cristo, Wash. October 1895, Prof. Mining University of Idaho, Moscow, Idaho.

GORDON, JOHN, JR., E. M., ... 1871.
G. O. Gordon, 69 Wall St., New York City.
Merchant, Edward Johnson & Co., 62 Sas Pedro, Rio de Janeiro, Brazil.

GOSLING, EDGAR BONAPARTE, E. M., PH. D., . . 1884.
Windsor Hotel, New York City.

Tutor in Mathematics, Columbia College from 1884 to 1885. Draughtsman and afterwards Assistant Engineer in Department of Docks, New York City, 1886–88. In Manufacturing Business in Paris, France, 1888–89. Tutoring in Mathematics and Engineering Branches in New York, and Superintending building of houses, introducing Culm-burning Furnace in U. S., 1889–91. In charge of erection of buildings in artifical stone (Beton Coignet), for the Suez Canal Company, Egypt.

GRAFF, CHARLES EVERETT, E. M., ... 1885.
50 Highland Ave., Jersey City, N. J.

1885–87, Assistant Engineer, Central Entre Riano Railroad, Argentine Republic, S. A. 1887–88, Engineer, Arizona Union Mining Co., Prescott, Arizona. 1888–90, Manufacturing Work, Binding Twine and Reapers. 1890–91, Engineer, Eagle Oil Co.

GRANGER, A. D., C. E., ... 1892.
Burhom & Granger, 136 Liberty St., New York City, and 22 Stuyvesant Ave., Brooklyn, N. Y.

Summer and Fall 1892, with C. W. Hunt & Co., and E. P. Gleason Mfg. Co., as draughtsman. November, 1892–November 1893, draughtsman, The Link Belt Engineering Co., New York branch. Member of firms of Burhorn & Granger from November 1893 to date.

GRATACAP, LOUIS POPE, PH. B. . . . . 1876.
Curator American Museum Natural History, Seventy-seventh St., and Eighth Ave., New York City, and West New Brighton (Richmond County), Staten Island, N. Y.

GREENLEAF JAMES LEAL, C. E., ... 1880.
Consulting Engineer, No. 1, Broadway, New York City, and Llewellyn Park, West Orange, N. J.

Special Agent for Tenth Census for Water-power from 1880 to 1882. Since instructing in engineering, civil and sanitary, in School of Mines, Columbia College. 1891, Adjunct Professor Civil Engineering, Columbia College. Resigned professorship in 1895 and gave exclusive attention to business as Consulting Engineer.

GREEN, DAVID JOY, C. E., ... 1894.
Standard Silica Cement Co., Flushing Street, Long Island City, and 300 Oakland Avenue, Brooklyn, N. Y.

GRISWOLD, WILLIAM TUDOR, C. E., ... 1881.
U. S. Geological Survey, Washington, D. C., and Boise City, Idaho.

GROSS, LOUIS NATHAN, B. S., E. M., ... 1884.
Merchant and 38 East Fifty-eighth Street, New York City.

GUDEMAN, EDWARD, PH. B., PH. D., ... 1887.
Davenport, Iowa., and P. O. Box, 3001, New York City.

Student at the Universities of Berlin and Göttingen, 1887–89. Private Assistant with Dr. C. F. Chandler, and Honorary Assistant at the School of Mines. 1889 and 1890, Professor of Chemistry in charge of the Department of Chemistry, Dye-

ing and Pottery at the Pennsylvania Museum and School of Industrial Art, Philadelphia, Pa. 1890–92, Chemist with the American Glucose Company at Buffalo, N. Y., and Peoria, Ill. 1892–93, Chemist in charge of Peoria Grape Sugar Company, at Peoria, Ill. 1893–95 Chemical Superintendent of the same. 1895, Superintendent Davenport Syrup Refining Company.

GUDEWILL, CHARLES EDWARD, C. E., ... 1890.
P. O. Box 874, Montreal, Canada, and 2 W. 47th St., New York City.

1890-91, Assistant in Engineering Department, School of Mines, under Prof. Trowbridge. 1891 to date, Assistant Engineer Dominion Construction Co., Montreal, Canada.

GUITERMAN, EDWARD WOLF, PH. B., ... 1889.
Davenport Syrup Refining Co. Davenport, Iowa.

1890-96, Chemist Passaic Print Works, Passaic, N. J.

H.

HAASIS, DUNBAR FERDNAND, E. M., ... 1883.
U. S. S. "Gedney," Box 173, and 83 Rector St., Perth Amboy, N. J.

1883-84, Inspector of bridge work, Stony Point, New York. 1885-88, Assayer and Chemist, afterwards General Manager Parral Mining and Milling Co., (silver), Mexico, 1889, with Corps of Engineers, U. S. A., on New York Harbor improvements. 1890 to date, Engineer Marion Phosphate Co., Florida, and Engineer Hamburg Phosphate Co., Florida. Surveying, prospecting and reporting on Phosphate deposits. 1892-93, with U. S. Engineers in charge construction Concrete Fortifications. In charge of Harbor Improvements. Assistant Engineer Dominion Construction Company for pipe laying and Reservoir engineering.

HAFFEN, LOUIS FRANCIS, A. M., C. E., . . . 1879.
Commissioner Street Improvements, One-Hundred and Forty-first St., and Third Ave., and 647 Cortland Ave., 23d Ward, New York City.

HALE, ALBERT WARD, A. B., A. M., E. M., . . 1867.
Department Public Works, East Twenty-fourth Street, and 81 Clinton Place, New York City.

HALL, ROBERT WILLIAM, E. M., ... 1876.
Chemical Building, University of New York, University Heights, 24th Ward, New York City.

From 1879 to 1888, Chemist to the American Gas Fuel and Light Company and to some associated companies. Since the autumn of 1888, Acting Assistant Professor of General Chemistry in the University of the City of New York. Since the autumn of 1890, also Acting Professor of Analytical Chemistry in the same institution. 1891, Professor of Analytical Chemistry, same institution.

HALLOCK, ALBERT PETER, PH. B., PH. D., . . . 1880.
440 First Avenue and 434 Lenox Avenue, New York City.

June, 1880, to October, 1880, with Dr. P. de P Ricketts. October, 1880, to November, 1887, Chemist Consolidated Gas Co. November 1887, to January, 1889, in the shell lime business. January, 1889, to date, Chemist to Carl H. Shultz, Mineral Water Factory. Specialty, Gas and Mineral Water Chemistry.

HAMILTON, FRANK C., E. M., A. M., ... 1894.
Assayer Brodie Gold Reduction Co., Cripple Creek, Colorado.

1894, Assistant Assayer Colorado Smelting Co., Pueblo Colorado. 1895 to date, Assayer Brodie Gold Red. Co., Cripple Creek, Colorado.

HANKINSON, ALBERT WORTHINGTON, C. E., . . . 1893.
114 West Forty-fifth Street, New York City.

HANNA, GEORGE BYRON, A. B., E. M., . . . 1868.
Charlotte, N. C.

Chemist and Assistant Geologist, North Carolina Geological Survey. Melter and Assistant Assayer U. S. Assay Office, Charlotte, N. C. Also Consulting Mining Engineer and Chemist, etc.

HANSON, R. C., ... 1894.
74 W. 91st St., New York City.

HARDING, GEORGE EDWARD (Associate), . . . 1867.
Architect, 253 Broadway, New York City.

Fellow American Institute Architects and Member American Society Civil Engineers.

HARRINGTON, THOMAS HENRY, C. E., ... 1889.
Columbia College, School of Mines, New York City, and West Chester, West Chester County, N. Y.

July, 1889, to March, 1893, Inspector Clerk and General Superintendent on U. S. Works, Flood Rock, Hell Gate, East River, N. Y. April to November, 1893, in charge of Exhibit of River and Harbor Improvements from New York City and Hudson River, at World's Columbian Exposition, Chicago. 1894 to date Asst. in Dept. Mechanical Engineering School of Mines, Columbia College.

HARRIS EDWIN, A., PH. B., ... 1889.
Secretary and Treasurer, Globe Steam Heating Company, 412 N. Eleventh Street, St. Louis, Mo.

1889–90, Chemist of the Camden Consolidated Oil Company. 1890 to date, Chemist Camden Consolidated Oil Company and agent for oil, mineral and timber lands in West Virginia and Ohio. Chemist to the Phosphorus Works of J. J. Allen's Sons, 2 Chestnut St., Philadelphia, 1892-93. April, 1893, to date, Secretary and Treasurer Globe Steam Heating Company.

HARTE, CHARLES R., C. E., ... 1893.
Box 136, Milford, Conn.

HASKELL, HARRY GARNER, E. M. . . . . 1893.
Wilmington, Del.

HAAS, EDWARD. F., C. E.,. . . . . 1894.
Stockton, Cal.

HATHAWAY, NATHANIEL, PH. B., ... 1879.
Swain Free School and 43 Elm Street, New Bedford, Mass.

1879–80, Booth and Edgar Sugar Refinery. 1880–83, Private Assistant to Dr. E. Waller, New York. 1883–91, Teacher of Chemistry and Physics, Swain Free School, New Bedford, Mass., and general analytical work.

HAWLEY, JOHN FRANCIS, C. E., (Life Member), . 1891.
Finca "El Tambor," San Filipe, Guatemala, C. America.

HERBERT, OCTAVE BRITTON, C. E., ... 1888.
D. B. Britton Co., 40 West Broadway, and 72 West 69th Street, New York City.

HEINSHEIMER, ALFRED MAURICE, C. E., . . . 1887.
Kuhn, Loeb & Co., 27–29 Pine Street, and 71 West Seventieth Street, New York City.

HENDRICKS, HENRY HARMON, PH. B., (Life Member), 1880.
Hendricks Bros., 49 Cliff Street, New York City.

HERCKENRATH, WALTER AUGUSTUS, A. M., C. E., . 1892
Address Unknown.

1892–93, Erie City Iron Works and with City Engineer on pavements and sewers; Wilmington, Vt., on Railway and General Engineering; Inspector U. S. Dredging Operations, Gowanus Bay. 1893, Temporarily employed in the Mathematical Department, University of Ottawa.

HEWLETT, JAMES MONROE, PH. BB., ... 1890.
Lord & Hewlett, Architects, 123 E. Twenty-third Street, New York City, and 77 Columbia Heights, Brooklyn, N. Y.

1893, With McKim, Mead and White, New York City. 1894, Formed partnership with A. W. Lord as architects.

HILDRETH, RUSSELL WADSWORTH, E. M., . . . 1885.
R. W. Hildreth & Co., Civil and Inspecting Engineers, Specialties Steam and Street Railways and Bridges, 50 Broadway, and 25 Madison Avenue, New York City.

Assistant Engineer in employ of George S. Morison from October 1, 1885, to January 1, 1890, on new Omaha Bridge (U. P. Ry.), Nebraska City Bridge (C., B. & Q. R. R.), Sioux City Bridge (C. & N. W. R. R.), over the Missouri River; the Willamette River Bridge, Portland, Ore., (O., R. & N. Co.); the Ohio River Bridge at Cairo (Ill. Cen. R. R.), and other structures.

Present co-partnership formed January 1, 1890, and since then have had charge of the following structures: Mill and shop inspection and superintendence of erection of Red Rock Cantilever (660 feet clear span), Colorado River Crossing, A. & P. R. R.; Susquehanna River Bridge, Panther Creek Viaduct, and other bridges Wilkes-Barre & Eastern R. R.; 155th Street Viaduct and Central Drawbridge, (McCoomb's Dam), New York City, and others. As Consulting Engineers, responsible for design, bridges, Wilkes-Barre & Eastern R. R., including Susquehanna River Bridge and Panther Creek Viaduct, Chattahoochee River Bridge (in-

cluding 330 feet draw), S. A. & M. R. R., Union Trust Company Building, Detroit, Mich., (a thirteen story, fire-proof, office building) and others.

HILDRETH, WALTER EDWARDS, C. E., E. M., . . 1877.
Metropolitan Hotel, 584 Broadway, New York City.

HILL, WILLIAM, C. E., ... 1882.
Agent Collins Company, Box 196, Collinsville, Conn.

One year practical experience in manufacture of crucible steel. Two years draughtsman and assistant to master mechanic of company manufacturing crucible steel, bar-iron, edge tools, plows and wrenches. Engineer in charge of reconstruction of dam 600 feet long, 32 feet high, at Otis, Mass. 1886 to date, Assistant Superintendent for the Collins Company, manufacturing principally edge tools. November 1st, 1891, appointed agent of the Collins Company, with general charge of plant at Collinsville, Conn., employing 650 men. 1892 to date agent of the Collins Company in general charge of works at Collinsville, Conn.

HINMAN, BERTRAND CHASE, PH. B., A. M. (1892), . 1890.
Supt. Nellie Bly Gold Mining and Reduction Co., and Box 46, Boulder, Colo.

Since June, 1890, Chemist to the Iron Clad Manufacturing Company, engaged in the manufacture of sheet-iron enamelled ware.

HOLBROOK, FRANCIS NEWBERRY, C. E., . . 1876.
42 Pine Street, New York City, and Box 395, Tarrytown, N. Y.

From fall, 1876, to spring, 1880, Assistant Assay Laboratory School of Mines. Spring and summer on Geological Survey, West Texas. Then to 1884, spring, Superintendent Corralitos Co., Chihuahua, Mexico. 1884–87, expert work, office, El Paso, Texas. Summer and Fall, 1887, Superintendent of United Verde Copper Company, Arizona. 1888, spring, on geological work for the Southern Pacific Company in West Texas. Summer and Fall, running gold mine and Mill for self in Arizona. 1889–90, Manager for U. S. Circuit Court in suit between the Con. Kansas City Smelting and Refining Company and the Guadalupe Company, in Nuevo Leon, Mexico. 1890 to February, 1891, employed by the Compañia Métalurgica Mexicana. March and April, 1891, charge of Copper smelter, Tucson, Arizona. Expert work until 1892, when returned to Comp. Metal, Mexico. Still employed by the Compañia Metalurgica Mexicana and the Mexican Northern Railway Co.

HOLDEN, EDWARD HENRY, C. E., ... 1878.
1074 Boston Avenue, New York City.

HOLLERITH, HERMAN, E. M., PH. D. (1890), . . 1879.
Electrician and Expert, 1054 Thirty-first St., Washington, D. C.

HOLLICK, ARTHUR, PH. B., ... 1879.
Columbia College, New York City and New Brighton, N. Y.

Superintendent Mexican Mine, Mariposa, Cal., 1880. New York City Health Department Inspector from 1881–90. Sanitary Engineer from 1890–91. Special Inspector, 1892. Special Expert and Inspector of Offensive Trades, New York State Board of Health, both in consultation and field work, from 1883 to date.

HUNTOON, L. D., E. M., ... 1895.
95 Bridge Street, Paterson, N. J.

August to November, 1895, Assistant Chemist Phila. Smelting and Refining Co.. Pueblo, Colo. December 1895 to date, Assayer American Reduction Co., (Cyanide Mill), Florence, Ala.

HURLBUT ELISHA DENISON, JR., C. E., . . . 1890.
106 Hicks Street, Brooklyn, N. Y.

1890–91, at Columbia College Law School. 1891–93, Assistant in Mechanical Engineering, School of Mines.

HUTTON, FREDERICK REMSEN, A. B., A. M., E. M., C. E.,
PH. D. (Life Member), . - . . . 1876.
Columbia College, and 296 Lexington Avenue, New York City.

1876–77, Assistant in Engineering, School of Mines. 1877–82, Instructor in Mechanical Engineering. 1882–91, Adjunct Professor Mechanical Engineering. 1891, Professor Mechanical Engineering.

HYDE, FREDK. HACKETT, PH. B., ... 1893.
38–40 Clinton Street and 215 Schermerhorn Street, Brooklyn, N. Y.

1893–94, Investigations in Glass for L. C. Tiffany, New York City. Assistant Chemist, Brooklyn Department of Health, May, 1894, to date.

I.

IHLSENG, AXEL OLAF, B. S., E. M., C. E., . . . 1877.
Carthage, Mo.

1877–82, Chief Chemist, Havemeyer Sugar Refining Co., Brooklyn, E. D. 1882–90, U. S. Dep. Mining Surveyor, District of Colorado. 1882–83, Chemist and Assayer, La Plata Smelter, Leadville, Colo. 1883, Metallurgist, Martha Rose Smelter, Silverton, Colo. 1884, Assayer, Stoiber Sampling Works, Silverton, Colo. 1885, Duyckinck, Schuyler & Ihlseng, Ore Samplers, Silverton, Colo. 1886–90, Manager of Mt. Queen Mining Co., Reliance Mining Co., Brown Mining Co., and the Hale Mines, Silverton, Colo. 1890–92, Operating Zincite Mine and others near Webb City, Nevada, and in constructing concentrating plants. Manager Pleasant Valley Mines, Carthage, Mo.

IHLSENG, MAGNUS C., E. M., C. E., PH. D., . . . 1875.
State College, Pa.

ILES, MALVERN WELLS, PH. B., PH. D. (Life Member), 1875.
Superintendent Globe Smelting Co., Denver, Colo.

1875–76, Assistant to Dr. Waller in the Qualitative Laboratory, School of Mines. 1876–78, Chemical Fellow, John Hopkins University. 1878–79, Assayer and Chemist, in Colorado. 1879–80, Assayer at the Smelting Works of J. B. Grant, Leadville, Colo. 1880–83, Chemist of the Grand Smelting Co., Leadville, Colo. 1883–86, Metallurgist, The Omaha & Grant, S. and R. Co., Denver, Colo. 1886–87, Metallurgist, The Holden Smelting Co., afterwards changed to the Globe S. & R. Co. 1887–95, in present position. Dr. Iles has contributed articles upon Assaying, various new Chemical methods, Mineralogy and Metallurgy in various publications.

INGERSOLL, WILLIAM HALSEY, A. B., A. M., LL. B., E. M. (Life Member), ... 1870.

Northport, Suffolk County, N. Y.

1875–78, Assistant in Engineering, Columbia College. 1878–81, Assistant in Mechanics and Astronomy. 1881–87, Manufacturing tinware, Portland, Conn. 1887, to date, Retired on account of ill health.

INGRAM EDWARD LOVERING, C. E., ... 1885.

403 D. S. Morgan Building, and 109 Prospect Ave., Buffalo, N. Y.

1885–86, U. S. Inspector of River and Harbor Improvements, Delaware. 1887–89, U. S. Surveyor and Inspector, River and Harbor Improvements, New York and New Jersey. 1890–91, U. S. Assistant Engineer, River and Harbor Improvements, Florida. 1891–94, Principal Assistant Engineer, International Boundary Survey, United States and Mexico.

J.

JACKSON, OSWALD, C. E., ... 1892.

550 Park Ave., New York City.

1892–93, Offices of Engineering M. W., U. R. R's. of N. J. Div., P. R. R. 1893, Engineer on Corps of Principal Assistant Engineer, U. R. R's. of N. J. Div., P. R. R. 1895, Assistant Engineer, the New York Steam Company.

JACOBS, DAVID MARK, PH. B., ... 1887.

R. J. Jacobs, 41 New Street, and 30 W. Thirty-eighth Street, New York City.

JACOBS, SOLOMON JOSEPH, PH. B., ... 1887.

R. J. Jacobs, 41 New Street, and 30 W. Thirty-eighth Street, New York City.

JANEWAY, JOHN HOWELL, E. M., ... 1886.

John A. Roebling's Sons Co., and 124 West State Street, Trenton, N. J.

1886, Underground and Surface Surveyor for Cooper, Hewitt & Co. 1887–91. Draughtsman and Designer and Constructing Engineer of Wire Rope Tramways in Montana, Oregon, Alaska and California for the Trenton Iron Co., Trenton, N. J.

JENKS, ARTHUR WILTON, E. M., ... 1886.

Seperintendent Establecimiento Mineral, Casapalca, Peru, S. Am.

Summer 1886, New Jersey on Geological Work. 1886–87, in Cerro de Pasco, Peru, S. A. Assayer and Chemist to the commission examining that silver mining district. Spring, 1887, In New York, Chemist with Ledoux & Co. 1887–88, In Aurora, Ill., Assistant at the works of the Chicago and Aurora Smelting and Refining Company. Summer and Fall, 1888, In Dutch Guiana, S. A., Assayer and Assistant in the examination of gold deposits. Fall 1888 to 1893, in Aurora, Ill., Assistant Superintendent at the Aurora Works of the Chicago and Aurora Smelting and Refining Co. 1883, Superintendent Kootenay Reduction Co. 1894, Superintendent Balbach Smelting and Refining Co., Newark, N. J.

JEUP, BERNARD JOHN THEODORE, C. E., . . . 1887.
Assistant City Engineer, 119 Walcott Street, Indianapolis, Ind.

JOBBINS, F. H., PH. B., ... 1895.
West Aurora, Ill.

JOHNSON, ARTHUR GALE, E. M., ... 1885.
Jensen, Utah.

JOHNSON, ELIAS MATTISON, PH. B., ... 1878.
Isaac G. Johnson & Co., Spuyten Duyvil, N. Y.

JOHNSON, GILBERT HENRY, PH. B., ... 1878.
Isaac G. Johnson & Co., Spuyten Duyvil, N. Y.

JOHNSON, ISAAC BRADLEY, E. M., ... 1879.
Isaac G. Johnson & Co., Spuyten Duyvil, N. Y.

JOHNSTONE, WM. B., C. E., ... 1895.
47 Central Avenue, New Brighton, S. I., New York.

JONES, JOHN ELMER, E. M., ... 1893.
Asst. Supt. Mill Creek Coal Co., NewBoston, Pa., and Hazleton, Pa.

JONES, WILLIAM DENISON, PH. B., ... 1888.
Hecker, Jones, Jewell Milling Co., 206 Produce Exchange, New York City, and 62 Clark Street, Brooklyn, N. Y.

JOPLING, REGINALD FURNESS, E. M., ... 1889.
Jopling & Escobar, Engrs., Room 508 Cuyahoga Bldg., Cleveland, O.

November, 1889, to February, 1890, Chemist, Otis Steel Co., Ltd. February, 1890–92, Assistant Manager American Wire Co. Vice-President of same, January, 1892.

JOUET, CAVALIER HARGRAVE, PH. B., PH. D., . . 1882.
104 John Street, New York City, and Roselle, N. J.

Analytical Chemist with Ledoux & Ricketts, 1882–85. Analytical Chemist with G. H. Nichols & Co., Acid Manufacturers at Laurel Hill, L. I., from 1885–88. Work comprising analyses of their various products and a partial supervision of their manufacture. Analytical Chemist from 1888 to present time with Ricketts & Banks.

K.

KASTNER, J. C., PH. B., ... 1894.
72 E. Ninty-second Street, New York City.

KELLY, WILLIAM, A. B., E. M., ... 1877.
Vulcan, Dickinson Co., Mich.

1876, '79, '80, Assistant Superintendent, Chemical Copper Co., Phoenixville, Pa. 1878, Chemist, Himrod Furnace Co., Youngstown, Ohio. 1881–84, Super-

intendent, Kemble Coal and Iron Co., Riddlesburg, Pa.; 1885, Superintendent, Glamorgan Iron Co., Lewistown, Pa.; 1886–89, Superintendent Kemble Iron Co., Riddlesburg, Pa.; In charge of Blast-furnaces, Coal Mines, Coke Ovens, Ore Mines, Quarries, Railroads, etc. 1880 to date, General Superintendent and Gen'l Manager Penn Iron Mining Co., Vulcan, Mich.; In charge of Iron-ore Mines on the Menominee Range, Lake Superior. Also, 1885-89, President Board of Examiners of Bituminous Mine Inspectors of Pennsylvania.

KEMP, JAMES FURMAN, A. B., E. M., ... 1884.

Prof. Geology, Columbia College, School of Mines, and 211 W. 139th St., New York City.

Several months with the Rand Drill Co., 1883–1874. Private Assistant to Prof. J. S. Newberry, 1884–85. Student of Geology and Mineralogy at the Universities of Leipzig and Munich, Germany, 1885–86. Instructor in Geology at Cornel, 1886–88. Assistant Professor of Geology and Mineralogy, 1888–91, and Secretary of the Faculty, 1888–89. Have traveled much in the West, and for five summers past have been working on the Geology of the Adirondacks, chiefly as Assistant to the State Geologist, Prof. Jas. Hall. Am especially engaged on Inorganic and Economic Geology. 1891, Adjunct Professor of Geology, School of Mines, Columbia College. Professor, 1892. Sec'y. N. Y. Acad. of Science since 1893. Editor School of Mines Quarterly, 1895–6, during absence of Prof. Moses.

KINSEY, FRANK WILMARTH, C. E., ... 1891.

50 Broadway, New York City, and 10 South Street, Newark, N. J.

Assistant to Engineers' Rapid Transit Commission, 1891–92. Engineer of Construction East Providence Water Works, 1892. Designing Engineer with S. M. Gray, 1892–93. 1893, Manager for R. W. Hildredth & Co.

KIRBY, G. T., E. E., ... 1895.

158 W. 45th St., New York City.

KISSAM, HENRY SNYDER, PH. B., ... 1886.

Architect Psi Upsilon Club, 33 W. Forty-second St., N. Y. City.

1888–89, Manager of Office of Pickles & Sutton, Architects, Tacoma, Washington. 1889–90, Practicing Architecture with P. W. Morris under firm name of Kissam & Morris, Tacoma, Washington. 1890–92, Practicing Architecture alone under name of Henry Snyder Kissam, Tacoma, Washington. 1892, Practicing Architecture with Jno. G. Proctor, under firm name of Proctor & Kissam, Tacoma, Washington. During 1893, in New York City, as Student of Special Construction.

KLEPETKO, FRANK, E. M., ... 1880.

Manager of Smelting Plants of Boston and Montana, Consolidated Copper and Silver Mining Co. at Great Falls, and of the Butte and Boston Mining Co. at Butte, Mont.

Superintendent Smelting Department, Tamarack, Osceola Copper Manufacturing Company, Collar Bay, Mich. At present Superintendent of Construction of the Great Falls Smelter, for the Boston and Montana Consolidated Copper and Silver Mining Company. Address, Great Falls, Montana.

KOCH, EDWARD CABOT, E. M., ... 1879.

Assistant General Manager, Elmore Gold Co., Limited, Rock Bar, Idaho, and 160 E. Fifty-sixth Street, New York City.

1880–82, Assayer and Chemist at Smelters, Leadville, Colo. 1883–88, Surveyor and Assistant Superintendent, L. A. G. Mfg. Co., Colo. 1889–92, Assistant General Manager E. G. Co., Ltd., and V. G. Co., Ltd., Rocky Bar, Idaho. 1892 to date, examining mining properties.

KOEN, JOSEPH JOHN, C. E., ... 1888.
Board of Health, 301 Mott Street, New York City, and Pearsalls, N. Y.

1889–90, Computer on New Croton Aqueduct. 1890–91, to date, Sanitary Engineer on New York City Board of Health.

KUNHARDT, WHEATON BRADISH, E. M. (Life Member), 1880.
Carpenter Steel Co., 1 Broadway, New York City.

1880–82, Travel and Study in the West and in Europe. 1883–88, Engineer for the Bower-Barff Rustless Iron Co., and Assistant of Geo. W. Maynard in consulting work on Iron-mines and Ore-dressing. 1888–89, First Assistant Engineer of the Boston Heating Co. 1890–91, Diamond Drill Exploration of Coal Deposits in Rhode Island. Report on Direct Steel Processes and on Magnetic Separations for Iron-ores. Acting Secretary of the American Institute of Mining Engineers for four months. 1893, President of the Osceola Placer Mining Company. 1874, with Carpenter Steel Co., 1 Broadway, New York City. 1895, Vice-President Carpenter Steel Co.

KURTZ, EDWARD LAURENCE, E. M., ... 1893.
17 Pittsburgh Street, New Castle, Pa.

L.

LACOMBE, CHARLES FREDERICK, E. M., . . . 1885.
The Mountain Electric Co., P. O. Box 1545, and 535–536 Seventeenth Street, and 1811 Grant Avenue, Denver, Colo. Also, University Club, New York City.

1885–86, Assayer and Surveyor and Foreman of Lucky Boy and South Galena Mines, in Bingham, Utah. 1886–88, Assistant Instructor in Assaying, and Fellow in Chemistry, School of Mines, Columbia College, N. Y. 1888–90, Examining Gold and Silver Mines in Colorado, Utah, Montana, Arizona and Old Mexico. 1890, Testing Electrical Apparatus in Virginia City, Nevada. 1890, Manager of the Gilpin Co. Light, Heat and Power Co., Central City, Colo. 1890 to date, President and Manager, The Mountain Electric Co. Specialty, Installing Electric Light and Power Stations, and adapting electric light and power for mining purposes.

LAHEY, JOSEPH, E. M., ... 1887.
162 E. Seventy-eighth Street, New York City.

LAHEY, RICHARD, E. M., ... 1887.
Wilson Bros. & Co., Drexel Building, Philadelphia, and 162 E. Seventy-eighth Street, New York City.

LAMB, ANDREW JOHNSON, E. M., ... 1884.
L. & N. R. R. Co., Gallatin, Tenn.

June, 1884, to June, 1887, New York Croton Aqueduct, Draughtsman. June, 1888, to Sept., 1890, Assistant Engineer, L. & N. Railroad. Sept. 1890, to June, 1891, Assistant Roadmaster, Knox Div., L. & N. Railroad. June, 1871, to date, Assistant Engineer L. & N. R. R. 1896, Roadmaster L. & N. R. R., Gallatin, Tenn.

LANGMUIR, ARTHUR C., ... 1893.
Chemical Department, Columbia College School of Mines, New York City.

LANGTHORN, JACOB S. (Associate) . . . . . 1891.
22 William Street, New York City, and 196 Joralemon Street, Brooklyn, N. Y.

LAWRENCE, BENJAMIN BOWDEN, E. M., . . . 1878.
Hooker & Lawrence, 810 Boston Avenue, Denver, Colo.

1878–84, Superintendent, Montezuma S. M. Co., and of other mines of Summit Co., Colo. 1884–91, Lessee and Operator of Mayflower and Pelican-Dives Mines, Clear Creek Co., Colo. In 1886, Formed partnership with W. A. Hooker, E.M., Class of 1869, with office at 145 Broadway, as Consulting Mining Engineers. I make a specialty of operating under lease or otherwise, true fissure Gold and Silver Mines, also Concentration of Gold-silver ores. 1893–94, Georgetown, Colo., at the Pelican-Dives Mines. 1895, Manager the Perigo Gold Mines, Colo.

LEARY, DANIEL JAMES, C. E., E. M., ... 1881.
43 East Twenty-fifth Street, New York City.

1882 to date, Constructing Highway and Railroad Bridges, Wharves, Docks, Dredging and Harbor Improvements generally, in vicinity of New York City, as Designing and Supervising Engineer, as well as Contractor in most instances. In general, make a specialty of both Engineering and Constructing work, or Engineering work alone, in this branch of the profession.

LEARY, GEORGE, C. E., ... 1891.
43 East Twenty-fifth Street, New York City.

LEAVENS, HARRY WENMAN, E. M., ... 1875.
Address unknown.

LEBOUTILLIER, CLEMENT, PH. B., ... 1881.
High Bridge, N. J.

1884–7, Assistant Chemist, Cambria Iron Co. 1887–92, Chemist, Eliza Furnace. March, '92, to date, Chemist, Taylor Iron and Steel Company.

LEDERLE, ERNST JOSEPH, PH. B., ... 1886.
Assistant Chemist, New York City Health Dept., 42 Bleecker Street, and 120 West Ninetieth Street, New York City.

1886–87, Hon. Fellow Quant. Anal. and Assist. Intr. Gen. Chemistry, School of Mines. 1887–88, Chemist, Cranmoor Farm, Tom's River, N. J. 1888–89, Asst. Chemist, New York City Health Dept. 1890–91, Chemist and Supt., Reed & Carnrick, New York. 1891–92, as above, specialties, food and food preparations. Lecturer on Chemistry and Director of the Chemical Laboratory, New York Dental School.

LEDOUX, ALBERT REID, M. S., PH. D. (Associate), . 1874.
Ledoux & Co., 9 Cliff Street, and 39 W. 50th, New York City.

LEE, GEORGE BARSTOW, E. M., ... 1885.
Superintendent Guggenheim Smelting Co., Maurer, Middlesex Co., N. J.

1885, Assayer, Butte, Montana. 1886–87, Assayer, Kansas City Smelting and Refining Co., Argantine, Kan. 1887–90, Assistant Superintendent, Rio Grande Smelting Co., Socorro, New Mexico. 1890-93, Superintendent, Rio Grande Smelting Co., Socorro, New Mexico. 1894, Superintendent, Guggenheim Smelting Co.

LEGGETT, THOMAS HAIGHT, E. M., ... 1879.
P. O. Box 485 Johannesburg, S. A. Rep.

1880, Assistant Engineer, New York River and Harbor Surveys. 1881–83, Superintendent of Mining Properties in the Batopilas District, Chihuahua, Mexico. 1884, Travelling in the West, through the principal Mining Camps, Butte, Leadville, etc. 1884-87, Mining Engineer to the New York and Honduras Rosario Mining Co., at San Juancito, Honduras. 1888, Manager of Mudsill Mining Co., Fairplay, Colo.; office, 23 Bucklersbury, London, E. C. 1889-90, General Manager, Darien Gold Mining Co., Ltd , of Cana, Rep. of Colombia. 1891–93, President and Manager, Standard Consolidated Mining Co.

LENOX, LIONEL REMOND, PH. B., ... 1888.
Assistant Professor Chemistry, Leland Stanford, Jr., University, Palo Alto, California.

After three years' work in the School of Mines, and previous to my senior year, I was respectively in : 1887, three months Assistant Chemist to Fulton Sugar Refinery. 1887, six months Assistant Chemist to Bethlehem Iron Co. 1888–89, Instructor in Qualitative Analysis and Assaying, Lehigh University. 1889-91, Instructor in Quantitative Analysis and Industrial Chemistry, Lehigh University. 1892–93, Chemist, Bureau of Ordnance, Washington, D. C.

LEVY, ALBERT LINCOLN, E. M., ... 1890.
810 Lexington Avenue, New York City.

LIBAIRE, EDWARD WILLIAM, C. E., ... 1894.
150 W. Forty-ninth Street, New York City.

LIEBMANN, ALFRED, C. E., ... 1893.
50 Broadway and 38 East Seventy-second Street, New York City, member of firm R. W. Hildreth & Co.

LILLIENDAHL, ALFRED WHIPPLE, E. M. (Life Member), 1883.
Superintendent, Mazapil Copper Co. (Ltd.), Concepcion del Oro, Estado de Zacatecas, Mexico.

1883–85, Assistant Supt. Aurora Smelting and Refining Co., Aurora, Ill. 1885–87, Assistant Supt. Grande Milling and Refining Co., Guanajuato, Mexico. 1888–93, Superintendent of the Mazapil Copper Co., Ltd., Concepcion del Oro, Zacatecas, Mexico. Superintendent, Coahuila and Zacatecas Railroad.

LILLIENDAHL, FRANK ARMSTRONG, E. M., . . . 1891.
Assistant Superintendent and Metallurgist, Mazapil Copper Co. (Ltd.), Concepcion del Oro, Estado de Zacatecas, Mexico (via Laredo, via Soltillo).
1891–96, as above.

LILLIE, SAMUEL MORRIS, E. M., ... 1874.
328 Chestnut Street, Philadelphia, Pa.
1874–75, Chemist, Kings County Refining Co., Green Point, L. I. 1876–85, Chemist, Franklin Sugar Refinery, Philadelphia, Pa. 1886–87, Sugar Engineer and Chemist, 1888–90, Vice-President and Manager of "The Sugar Apparatus Manufacturing Co.," a Company organized under the Laws of Pennsylvania, to operate under his patents. 1891, President of said Company.

LIPPS, HENRY, JR., C. E., ... 1888.
Address unknown.
From July, 1888, to August, 1889, Assistant Engineer Maint. of Way, Dep. R. & D. R. R., W. N. C. & Va. Mid. Div. August, 1889, to January, 1890, Supervisor Track, N. C. Div. R. & R. R. January, 1800, to date, Engineer Maint. of Way, N. C. Div. R. & D. R. R.

LITTLE, WILLARD PARKER, E. M., PH. B., . . . 1881
Architect, 28 West Twenty-third Street, New York City.

LIVINGSTON, ARCHIBALD ROGERS, C. E., . . . 1891.
20 North Washington Square, New York City.
Since November, 1891, in employ of Lackawanna I. & S. Co., Scranton, Pa.

LONGACRE, LINDSAY B., M. E., ... 1892.
Spuyten Duyvil, N. Y.

LORD, FREDERICK REUBEN, C. E., ... 1892.
General Manager, Clifton Coal Co., Bay Street cor. Vanderbilt Ave., Clifton, and Box 228 Stapleton P.O., Richmond Co., N. Y.

LOVE, EDWARD GURLEY, A. M., PH. B., PH. D., . . 1876.
Analytical and Consulting Chemist, Gas Examiner, Department Public Works, 122 Bowery, and 80 East 55th Street, New York City.

LUDLOW, EDWIN, E. M., ... 1879.
Superintendent Choctaw Coal and Railway Company, Hartshorn, Indian Territory.
1879–81, Assistant Engineer in charge of hydrographic work on Delaware River under U. S. Engineer. 1881, Assistant Engineer Mexican National Railroad, Mexico. 1882–89, Assistant Superintendent, then Superintendent, for Pennsylvania Railroad coal-mines at Shamokin, Pa. 1889, to date, Superintendent of Mines, Choctaw Coal and Railroad Company, Hartshorn, Indian Territory.

LUQUER, LEA MCILVAINE, C. E., PH. D. (1894), . . 1887.
Tutor in Mineralogy, School of Mines, New York City, and Bedford, N. Y.

Summer of 1887, Assistant in Geodetic Surveying with Professor Rees. Summer of 1887, Assistant in Surveying with Professor Monroe. Summer of 1888, Assistant in Geodetic Surveying with Professor Rees. 1887–90, Fellow in Mineralogy, School of Mines. 1890, Assistant in Mineralogy, School of Mines. 1891 to date, Tutor in Mineralogy, School of Mines. 1895–6, Lecturer and Instructor in Mineralogy during absence of Professor Moses in Europe.

LUQUER, THATCHER TAYLOR PAYNE, C. E., E. E. (1892), 1889.
Care of Metropolitan Telephone and Telegraph Co., 18 Cortlandt Street, New York City, and Bedford, N. Y.

1890, Fellow in Engineering. 1890–91, Fellow in Surveying and Practical Mining. 1891, Assistant in Mining, Columbia College, School of Mines. 1892, with H. Ward Leonard & Co., New York City. 1893, Engineer, Union Electric Co., New York City. 1894, Engineer the Fiber Conduit Company, New York City. 1895, Engineering Dept. M. T. & T. Co.

LUSK, GRAHAM, PH. B., PH. D. (Munich, 1891), . . 1887.
Assistant Professor of Physiology at the Yale Medical School, New Haven, Conn. Address: 47 East Thirty-fourth St., N. Y. City.

1887–1888, Student at Munich. 1889, Student at Munich; also at Bellevue Hospital Medical College, N. Y. 1890, Studied at Bellevue; afterwards in Munich. 1891, Studied in Munich; and was later appointed Instructor of Physiology at the Yale Medical School. 1892, Assistant Professor of Physiology.

LUTTGEN, EBERHARD, PH. B., ... 1884.
Wissahickon Chemical Works, Ambler and Chelten Hills, Wyncote P. O., Pa.

1884–85, Assistant Chemist, Crane Iron Company, Catasauqua, Pa. 1885 to date, Chemist and Manager, Keasbey & Mattison's Chemical Works, Ambler, Pa, Specialty, manufacture of magnesia.

LYMAN, FRANK, A. B., M. E., ... 1878.
Deputy Commissioner City Works, Room 15 Municipal Building, and 50 Remsen Street, Brooklyn, N. Y.

M.

MCCULLOH, EDWIN AUSTIN, PH. B., ... 1878.
Glencoe, Md.

MCILHINEY, PARKER C., A. M., PH. D., . . . 1892.
School of Mines, Columbia College, New York City, and 72 Monticello Ave., Jersey City, N. J.

Summer of 1892, Chemist Fibre Pipe Co. 1893–94, Hon. Asst. in Assaying. 1894, Asst. in Metallurgy.

MCKENNA, CHARLES FRANCIS, PH. B., ... 1883.
221 Pearl St., and 144 W. Ninety-Ninth St., New York City.

1883–84, Chemist Havemeyer Sugar Refining Company, Jersey City, N. J. 1885–86, Chemist Cambria Company, Johnstown, Pa. 1887–90, Chemist Edge-

water Lime Works, Edgewater, N. J. 1890, Chemist Jas. J. McKenna & Bros., Brass Founders, 424, 426 East Twenty-third Street, New York City. 1893, Director, Physical Testing Department, Laboratories, Dr. G. E. Moore, 221, Pearl street, New York City.

McKim, Robert Albert, C. E., ... 1884.
Room 213, 280 Broadway, New York City, and Rochelle Park, New Rochelle, N. J.

Assistant Engineer on New Croton Aqueduct. (Entered Aqueduct Engineer Corps as Chainman, in February, 1885.)

McKinlay, Wm. Bradford, E. M., ... 1895.
108 W. Seventy-ninth St., New York City.

McLaughlin, Charles Swain, Ph. B., . . 1884.
874 Broadway and 2041 Fifth Avenue. New York City.

MacKaye, Harold Steele, C. E., ... 1887.
Westinghouse Electric and Mfg. Co., 120 Broadway and 597 West End Avenue, New York City.

Three months' work in New York Harbor in Army Corps of Engineers. One year's employment in the Office of Patent Solicitors. 1889–92, acting as Fourth Assistant Examiner of the U. S. Patent Office. Since July, 1892, Patent Counsel for Westinghouse Electric and Manufacturing Company.

MacTeague, John Joseph, E. M., ... 1883.
Address unknown.

Maclay, James, C. E., ... 1888.
Tutor in Mathematics, Columbia College, and 87 Union Street, Newark, N. J.

Mahony, Arthur Stuart, E. M., ... 1889.
51 West Ninety-fourth street, New York City.

1890, First Assistant General Manager of the New Birmingham Iron and Land Company. 1891, Treasurer of the same company, also Chemist to the Tassie Belle Furnace, New Birmingham, Texas. 1893, Contractor.

Malukoff, A. J., ... 1893
15 Winthrop Street, Boston, Mass.

Mannheim, Hermann Charles, E. M., . . . 1887.
Care of R. A. Parker, Johannesburg, S. A. R. South Africa.

Mannheim, Paul August Louil, E. M., . . . 1885.
United Smelting and Refining Company, East Helena, Montana.

Marié, Leon, E. M., ... 1885.
12 East Forty-sixth Street, New York City.

Marsh, John Rollin, E. M., ... 1887.
Address unknown.

1887, Chief Engineer, Indiana Bridge Company.

MARTIN, EDWARD WARD (Associate), ... 1877.
Chemist, Board of Health, 301 Mott Street, New York City.

MASSA, CHARLES GRISWOLD, C. E., ... 1889.
Fort Lee, N. Y.

Since October, 1889, on varied engineering work, including: Topographical Survey, Greenwood Lake, N. Y., 1889; Structural Steel Shop Inspection with R. W. Hildreth & Co., at Phœnixville, Pa., 1890, and at Harrisburg, Pa., 1894; Construction Lehigh Valley Ry. Extension, Geneva, N. Y., 1890; Street Railway Construction, Allegheny, Pa., 1890–91; R. of W., Maintenance, Construction, Northwest System, Penna. Lines, 1891–93; Construction, Masonry, Dam, Etc., Newton, N. J., Water Works, 1895.

MASSA, LOUIS FERDINAND, C. E., ... 1890.
136 Liberty Street, New York City, and Fort Lee, N. J.

October, 1890–92, shop practice, Maryland Steel Works, at Sparrow's Point, Md., as follows: October, 1890, to July, 1891, Machine-shop practice. July, 1891, to September, 1891, Bessemer Mill Construction. September, 1881, to September, 1892, Bessemer Rail-mill and Roll-house; Mechanical and Metallurgical Engineering. October, 1892–93, Post-graduate Electrical Engineer at Columbia College. February, 1894, to date, Electric Constructing, W. H. Freeman & Co., 136 Liberty Street.

MASTERS, H. K., E. M., ... 1894.
In care of Laurel Hill Chemical Co., Laurel Hill, L. I., and 173 Congress Street, Brooklyn, N. Y.

MATHIS, THEOPHILUS SMITH, E. M., ... 1879.
Engineer of Mines, and U. S. Surveyor General's Office, and 529 East Street, Salt Lake City, Utah.

From January, 1890, to February, 1891, Assistant Draughtsman U. S. Surveyor General's Office, Salt Lake City, Utah. Since Februery, 1891, Chief Draughtsman of Mineral Division of said Office, and still holds that position.

MAYER, RALPH EDWARD, C. E., ... 1879.
Instructor in Mechanical Drawing, School of Mines, Columbia College, New York City.

MEISEL, F. C. A., PH. B., ... 1892.
Examiner Chemist, U. S. Laboratory, 402 Washington St., N. Y. City.

MEISSNER, CARL AUGUST, PH. B., ... 1880.
General Mgr. Londonderry Iron Co., Londonderry, Nova Scotia.

One year, Assistant Chemist Joliet Steel Company. Three years, Chemist and Assistant Superintendent Brier Hill Iron and Coal Company, Youngstown, Ohio. One and a-half years, Head Chemist Joliet Steel Company. Three years, Manager Sterling Iron and R'wy Company, Sterlington, N. Y. At present, Vice-President and General Manager of the Vanderbilt Steel and Iron Company, Birmingham, Ala., after having personally organized this company. President Jefferson County Mining and Quarrying Company.

MELLISS, D. ERNETS, A. M., PH. D. (Associate), . . 1868.

Price's Building, 524 Sacramento Street, San Francisco, Cal.

Student regular course, three years, School of Mines. Afterwards, two and a-half years University of Goettingen, graduating Ph.D., in 1869. One year at University of Vienna. Since then, constantly occupied in civil and mining engineering. In 1873 was Chief Engineer in charge of Topographical and Geological Survey of Guanocaste and Nicoya for the Costa Rican Government. In 1881, Consulting Engineer to the Pacific Gas Light Company, of San Francisco, and in its interest studied the different gas-making systems in the United States, England, France and Belgium. Have made plans for and erected numerous gold, silver, copper and lead mines. Planned the Union Iron Works, of San Francisco, and superintended their construction ; also the Arctic Oil Works and several other industrial establishments on the Pacific Coast. Designed and built the Mazatlán Water Works, in Mexico ; the Hydraulic Press Brick Works, of California, the largest establishment of its class on the Pacific Coast. Four years in Central America and Mexico. Was Administrator of San Josà de las Bocas and Consulting Engineer to Guadalupe de los Reyes, the most successful silver mine of Sinaloa. Now Consulting Engineer in San Francisco, and particularly occupied in that capacity for the Olympic Salt Water Company, whose works are now being erected under his supervision and according to his plans.

MERRILL, FREDERICK JAMES HAMILTON, PH. B., PH. D., 1885.

State Museum, and 2 Sprague Place, Albany, N. Y.

1885–87, Assistant on the Geological Survey of New Jersey. 1886–90, Fellow in Geology, Columbia College. 1890 to date, Assistant State Geologist and Assistant Director of the New York State Museum, Albany, N. Y.

MERRITT, JAMES HAVILAND, PH. B., A. M., . . . 1880.

Care of Grenville Temple Snelling Company, E. 49th St., New York City, and 3 Munroe Place, Brooklyn, N. Y.

From 1881–88, Chemist to the Bradley White Lead Co. In 1889, entered the School of Mines as Post Graduate in the course of Architecture. 1892–93, Architectural Study.

MERZ, EUGENE, E. M., ... 1892.

Box 112, and 143 Littleton Ave., Newark, N. J.

MESEROLE, WALTER MONFORT, C. E., ... 1881.

189 Montague St., and 2789 Atlantic Avenue, Brooklyn, N. Y.

1881, Transitman and Topographer Continental Railway Co. 1881–83, Assist. Eng. in Construction, N. Y., West Shore and Buffalo Ry. 1884–85, Division Engineer Maintenance of Way ; 1885, Chief Engineer Catskill Mountains and Cairo Railway. 1885, in charge Topographical Survey for Kings County Charities' Commission. 1886 to date, in General Practice, located at Brooklyn, N. Y. Specialties: Improvement and Development of Real Estate and Surveying for Legal and Construction Purposes ; City Surveyor of the City of Brooklyn ; Chief Engineer South Brooklyn R. R. and Terminal Company, German-American Improvement Company and Hancock and State Line Railway Company.

MESSITER, E. H., C. E., ... 1894.

133 W. 84th St., New York City.

1889, Draughtsmen, New Croton Aqueduct, 1891 (Summer vacation), Draughtsman, Mfg. Investment Co., Madison, Me. Mill Construction, June, 1894, to November, 1894. Inspector under Wm. Barclay, Parsons, C. E. November, 1894, June, 1895, Engineer Guggenheim Smelting Co., Perth Amboy, N. J. June, 1895, to date, Chief of Party. Surveys for Rapid Transit Commission, N. Y. City.

MEYER, HERMAN HENRY BERNARD, E. M., . . . 1885.
539 W. Twentieth Street, New York City, and 844 Putnam Avenue, Brooklyn, N. Y.

Surveying, Field and Office work at Pelham Park, Westchester Co., July to November, 1895. December, 1895, to date, Engineer for Oregon Iron Works, New York; designing and erecting machinery for manufacturing illuminating gas.

MIDDLETON, JOHN, C. E., ... 1887.
2789 Atlantic Avenue, and 14 Glenade Place, Brooklyn, N. Y.

1888 to date, Surveyor, Assistant to W. M. Meserole, C. E.

MILLER, CHARLES LEWIS, E. M., ... 1885.
Illinois Steel Company, 3179 Ashland Avenue, and 3609 Ellis Avenue, Chicago, Ill.

1886, Assistant Chemist Edgar Thomson Steel Works, Braddock, Pa. 1886–87, Chemist and Assistant Supt. Carbon Iron & Pipe Co., Parryville, Pa. 1887–90, Supt. The Missouri Furnace Co., St. Louis, Mo. 1890 to date, Supt. Blast Furnaces at Union Works of Illinois Steel Co., Chicago, Ill.

MILLER, CHARLES WATTS, E. M., ... 1884.
Box, 401, Aspen, Colo.

1884–85, Metallurgical Engineer Hecla Bronze and Iron Works. 1885–86, Assayer and Chemist, Aspen, Colo. 1886–91, Mining Engineer and United States Deputy Mineral Surveyor, Aspen, Colo. General mining engineering business.

MILLER, EDMUND HOWD, PH. B., A. M. (1892), PH. D. (1894), ... 1891.
Assistant in Assaying, Columbia College, School of Mines, and West Nyack, Rockland Co., N. Y.

1892–93, as above. 1894, Tutor in Analytical Chemistry and Assaying, School of Mines.

MILLER, RUDOLPH PHILIP, C. E., ... 1888.
141 East Fortieth Street, New York City.

1888–1890, Assistant to E. M. W., 1890–94, Supervisor R. and D. Railway till April, 1894. August to November, 1894, with W. S. Miller, Builder, New York City. November, 1894, to October, 1895, with Long Island R. R. as transitman and assistant. December, 1895, to date, with Department of Buildings, New York City.

MILLER, SAMUEL O., C. E., ... 1895.
West Nyack, N. Y.

MILLIKEN, GEORGE FANSHAWE, E. M., . . . 1870.
Land Department, N. P. R. R., Tacoma, Wash., and Union League Club, New York City.

1879-80, Superintendent "Milton Mining Company." 1880-83, General Manager "Chester Mining Company." 1883-87, in General Consulting Practice as Engineer. 1887-90, General Manager "Costa Rica Mining Co., Ltd." 1890, to date, Consulting Engineer Northern Pacific Railroad.

MOLDEHNKE, RICHARD GEORGE GOTTLOB, E. M., PH. D., 1885.
McConway & Torley Co., Forty-eighth Street and A. V. R.R., and 164 Home Street, Pittsburgh, Pa.

1885-87, Three Summer seasons with United States Coast and Geodetic Survey, New York and Philadelphia Harbors and Cape Cod, Mass., *Hydrographic Work*, Triangulation, Levelling, etc. 1885-86, Winter, nine months, *Sanitary Engineering*, Inspector, etc., New York Association for Improvement of Condition of Poor. 1887-89, *Electrical Engineering*, five months Mining Engineer Sprague Electric Railway and Motor Co., seven months Mechanical Engineer Crocker-Wheeler Motor Co., five months experimenting on patents taken out. 1889, Manufacturing for myself. Specialty in Machinists' Tools. 1889-90, Professor Mechanical and Electrical Engineering, Michigan Mining School, Houghton, Mich. 1890, to date, Engineer McConway & Torley Co. Expert in Malleable Castings.

MONELL, JOSEPH THOMPSON, C. E., ... 1889.
136 Liberty St., and 236 W. Twenty-second St., New York City.

1891, Electrical Engineering, Curtis Electrical Mfg. Co. 1892, Tutor in Astronomy, Columbia College.

MONTENEGRO, MANUEL RAFAEL, E. M., . . . 1890.
539 W. 20th Street, New York City, and 53 Washington Street, Hoboken, N. J.

1890, Spiral Weld Tube Company, East Orange, N. J., and studying machine-shop practice. 1891-92, engaged in the formation of mining companies. 1892 to date, Assistant Superintendent Oregon Iron Works, New York City.

MORA, MARIANO LUIS, C. E., ... 1891.
Columbia College School of Mines, and 63 W. Seventieth Street, New York City.

Graduate Post-graduate Course Electrical Engineering, 1894.

MORAN, DANIEL EDWARD, C. E., ... 1884.
Sooysmith & Co., Mills Building, and 26 W. Eighteenth Street, New York City.

MORGAN, WILLIAM FELLOWES, A. B., E. M. (Life Member), 1884.
Brooklyn Bridge Freezing and Storage Co., Arch 4 Brooklyn Bridge, New York City, and Short Hills, N. J.

1884-88, Banking and Brokerage. 1888 to date, as above.

MORRIS, GOUVENEUR WILLIAM, E. M., ... 1878.
11-13 William Street and 123 W. Thirty-fourth Street, New York City.

Banker and Broker.

Gold Mining Company, Cripple Creek, Colorado. 1893, as above. 1894, Mining Engineer, Colorado Springs.

NEWBROUGH, WILLIAM, A. B., E, M., ... 1884.
Evanston, Wyoming, and 371 Herkimer Street, Brooklyn, N. Y.

NEWHOUSE, EDGAR LIEBER, E. M., ... 1886.
75 and 77 Worth Street, New York City.

NICHOLS, RALPH, E. M., C. E., ... 1877.
Superintendent, De La Mars, Nev. G. Mg. Co., Delamar, Lincoln Co., Nevada.

1878, Ore Sorter, Hukill Mine, Idaho Springs, Colo. Later, Assistant in F. E. Brown's Civil and Mining Engineering office, Georgetown, Colo. Later, Assayer and Chemist La Plata M. and S. Co., Leadville, Colo. Appointed U. S. Deputy Mineral Surveyor in 1879. 1879-82, Civil and Mining Engineer at Leadville, Colo., with following firms: Page, Nichols & Co., and Nichols & Dunham. Superintendent Farwell Cons. Mining Co.'s Gold Mill at Independence, Colo. Superintendent of the Big Pittsburg Cons. Mining Co., Leadville. 1883, Superintendent of the Viola Mining and Smelting Co. Later General Manager of same until 1891. Since then have been mining and working mines on lease. Examined mines in Colorado, Idaho, Nevado, and Mexico. 1894, General Superintendent The Comstock Tunnel Co. Interested in mines in Colorado and Idaho, and am working mines in Idaho under lease. Have acted as ore buyer for the Cons. Kansas City S. and R. Co., and am at present representing the Globe S. and R. Co., in this State.

NOBLE, LOUIS SPENCER, E. M., ... 1885.
Leadville, Colo.

1885-89. Mining Engineer to Iron-Silver Mg. Co., and Nisi Prius Cons. Mg. Co., of Leadville, Colo. Also during 1889 Consulting, Reporting and Lawsuit work on other Colorado properties. 1889-90, Superintendent of Mines and Mining Engineer to Constancia Mining and Smelting Co., at Sierra Mojada, Coahulia, Mexico. 1890-91, Mining Engineer on Lawsuit preparation, with Blue Bird Mining Co., Ltd., of Butte, Montana. Specialty, Lead, Silver and Gold Mines and Mining.

NOLAN, THOMAS, M. S., PH. B., ... 1884.
Nolan, Nolan & Stern, Architects, 1017 Chamber of Commerce Building, Rochester, N. Y.

NORRIS, DUDLEY HIRAM, E. M., ... 1877.
Address unknown.

NORRIS, ROBERT VAN ARSDALE, E. M., . . . 1885.
Assistant Engineer, P. R. R., Dept. of Anthracite Coal, Room 28, First National Bank Building, and 24 S. Franklin Street, Wilkesbarre, Pa.

1885, Assistant in Practical Mining and Surveying, School of Mines. U. S. Inspector of Dredging, in charge of Maurice River Improvement, Millville, N. J. 1886, Chemist, Herman Behr, Manufacturer of Colors, Brooklyn, N. Y. June,

1886, to date, Assistant Engineer, Pennsylvania Railroad Department of Anthracite Coal Collieries. Specialty, Mechanical Engineering of Collieries.

NORTON, LUCIEN HOLLEY, E. M., ... 1886.
Penna. Smelting Co., Sandy, Utah.

1887–1890, Engineering Office, N. Y., N. H. & W. R. R. Experience in Railroad Construction, Location and Preliminary Surveys, Office Work and General Surveying. 1890, Assayer and Engineer to West Indian New Gold Mining Corporation, San Domingo, West Indies. Experience in Free Melting of Gold-ores, Assaying, Surveying, etc. January, 1891–92, Assayer for Daly Mining Co., Park City, Utah. Experience in Assaying, General Analyses. Also Leaching of Silver-ores by the Russell Process. 1892 to date, as above.

NOYES, JAMES ATKINS, PH. B., A. B. (Harvard, '83),
(Life Member), ... 1878.
71 Sparks St., Cambridge, Mass.
Editor Quinquennial Catalogue, Harvard University.

NOYES, WILLIAM SKAATS, E. M., ... 1875.
Shafter, Presidio County, Texas, and 2023 Summit Street, Oakland, Cal.

1877–1879, Assayer for McCrackin Mining Co., Mohave Co., Arizona. 1879–1881, Foreman of Bodie Mill, for Bodie Coal Mining Co., Bodie, Cal. 1881–1883, Examining Mines for San Francisco Capitalists. 1883 to present time, Superintendent of Presidio, Mining Co., and The Cibilo Creek Mill and Mining Co., Shafter, Presidio Co., Texas.

NYE, ALVAN CROCKER, PH. B., ... 1884.
Hayden Furn. Co., 1 West Thirty-fourth St, and 107 E. Seventieth Street, New York City.

1884–85, Draughtsman, C. C. Haight, Architect, New York City. 1885–90, Designer and Head Draughtsman, Herter Brothers, New York City. 1890 to date, Furniture Designer and Architect, The Tiffany Glass Co., New York City. 1892, Chief Designer as above.

O.

O'CONNOR, MICHAEL JOSEPH, E. M., PH. B., . . 1881.
Architect (1884), 28 W. Twenty-third Street, New York City.

O'CONNOR, THOMAS DEVLIN, PH. B., ... 1881.
O'Connor & Elliot, 16 Exchange Place, and 12 E. Forty-fourth Street, New York City.

OLCOTT, EBEN ERSKINE, E. M., ... 1874.
Mining and Metallurgical Engineer, 18 Broadway, and Gen'l Mgr. add Treas. Hudson River Day Line, Desbrosses Street, also 38 W. Thirty-ninth Street, New York City.

1874–75, Chemist to Ore-Knob Copper Co., in charge of Hunt & Douglass Process. 1875–76, Assistant Supt. Penna. Lead Co.'s Works, Mansfield Valley, Pa.

1876–78, Assistant Supt. Orinoco Exploring and Mining Co., at their Gold Mines in Venezuela. 1878–79, Supt. of the same. 1879–81, Examining Mines in Colorado, Utah, Nevada and California, for New York Investors. 1881–85, Supt. St. Helena Gold Mines, Sonora, Mexico. 1885, opened office in New York as Consulting Engineer, and since then has been engaged as Consulting Mining and Metallurgical Engineer, in Peru, Republic of Colombia, Dutch and British Guiana, Mexico, British Columbia, Ontario, New Brunswick, and the United States. 1895, Consulting Mining Engineer and Genl. Mgr. Hudson River Day Line.

ORMSBEE, JAMES JACKSON, E. M., ... 1886.

Superintendent Tenn. Coal, Iron & Ry. Co., Henry Ellen, Ala.

1886–91, Mining Engineer of Tracy City Division of Tennesee Coal, Iron and Railroad Co. 1891–92, Superintendent, Thomas Coal Mines, of Tennessee Coal, Iron and Railroad Co., Whitwell, Tenn. 1892–94, Engineer and Superintendent Sequachee Valley Coal and Coke Co. 1894, Superintendent Poplar Creek Div. Tenn. Coal, Iron and Railroad Co.

OSTERBERG, MAX, E. E., ... 1894.

113 East Sixty-fifth Street, New York City.

Summer '94, after graduation : Editor of the *Proceedings* of the Chicago Electrical Congress. Practical shopwork in a dynamo factory. October 1st, Appointed Associate Editor of *Electric Power*. During season '94–'95, Instructor of Electrical Engineering at the National School of Electricity, at the Y. M. C. A. in New York City and Stamford, Conn. Fall '94, Reëntered College to pursue postgraduate studies. June '95, was appointed University Fellow in Mechanics. January '96, Author of "*Synopsis of Current Electrical Literature.*"

OSTERHELD, THEODORE W., E. M., ... 1886.

Chief Engineer, Coahuila and Zacetecas R. R., Gomez Farias, Coahuila, Mexico.

Assistant Superintendent of Blast furnaces, P, S. Co., 1886–87. General Foundry Practice, Worthington P. Works, 1887–88. Owner of Foundry and General Iron Works, 1888–89. Vice-President, Pendleton Mining Co., and Consulting Engineer, 1889, '90, '91, and General Consulting Engineer, Iron and Coal Specialty, and Metallurgist of Iron and Finished Manufacturing. Interval of 1880–91, of the months December to May, Superintending Construction of Rolling Mill, Southwest Virginia. Specialty, Coal and Iron of the Virginias. President of the Southern Reducing Co., Experts, Chemists and Mining Engineers.

OWEN, FREDERICK NASH, E. M., ... 1878.

Civil and Sanitary Engineer, 58 West Ninety-first Street, New York City.

P.

PAGE, GEORGE STEPHEN, E. M., ... 1885.

Care of Park Bros. & Co., Limited, Pittsburg, Pa.

1885–86, Assistant Chemist Edgar Thompson Steel Works. From July, 1886, to date, Manager of Steel Works with Park Bro. & Co., Ltd. Specialty : Manufacture of Open-Hearth and Crucible Steel.

PAGE, WILLIAM STEVENS, E. M., ... 1882.
Aqueduct Commission, Sing Sing, N. Y.

PAINTER, CHARLES ALBERT, E. M., ... 1884.
J. Painter & Sons, Pittsburg, Pa., and 208 Western Avenue, Allegheny City, Pa.

PAINTER, GEORGE EDWARDS. PH. B., ... 1883.
J. Painter & Sons Co., Pittsburg, Pa., and 210 Western Avenue, Allegheny City, Pa.

PARKER, ANDREW MCCLEAN, E. M., ... 1880,
Acting 1st Assistant Engineer, Dept. of Docks, Pier A, and 35 W. One Hundred and Nineteenth Street, New York City.

PARKER, HERSCHEL CLIFFORD, PH. B., ... 1890.
Dept. of Physics, Columbia College, New York City, and 21 Ft. Green Place, Brooklyn, N. Y.

1890–91, Fellow in Physics, Assistant Instructor, Course in Physical Measurements. 1891–93, Assistant. 1893–95, Tutor in Physics.

PARKER, RICHARD ALEXANDER, C. E., ... 1878.
Consulting Mining Engineers, 403 Lyceum Bldg., Duluth, Minn., and East Ohio Street, Marquette, Mich.

1878–79, Assistant Superintendent, Montezuma Silver Mining Co., Montezuma, Colo. 1880–81, Surveyor at Georgetown. 1881–82, Chief Draughtsman, Mexican Natl. Cons. Co., Laredo, Texas. 1883–84, Examining Mines in Colorado, Utah and Idaho mainly. 1885–86, Superintendent, Atlanta Hill Gold Co. Also Superintendent of the Big Lode (Gold) Co., Atlanta, Alturas Co., Idaho. 1887 to date, Resident Manager and Agent for Samson Iron Co., Imperial Iron Co., and Barasa Iron Co. Also Consulting Mining Engineer. Specialties, Gold and Silver Mining and Milling, and Iron-ores. Manager of Steel Works.

PARKS, JOHN RANDOLPH, E. M., ... 1880.
Helena, Mont.
Consulting Mining Engineer.

PARRAGA, CHARLES FREDERICK, C. E. (Life Member), . 1883.
58 William Street, and 145 W. Ninety-seventh Street, New York City.

1883–84, Inspector of Construction of Bridges and Railroad Material in Europe. 1884–86, Railroad Engineer in Colombia, S. A. 1887 to date, General Expert Business. 1891, Delegate from Colombia to the Inter-Continental Railway Commission at Washington, D. C.

PARROT, EDWARD MOORE, E. M., ... 1870.
Ontario, Wayne County, N. Y.

PARSONS, HENRY, C. E., ... 1888.
Vice-President City and Suburban Ry., Savannah, Ga., and 1033 Madison Avenue, New York City.

PARSONS, WILLIAM BARCLAY, A. B., C. E., . . . 1882.
22 William Street, and 51 East Fifty-third Street, New York City.
Previous to graduation served as Assistant Engineer Arnot and Pine Creek Railroad and Blossburg Coal Mine. After graduation entered Maintenance of Way Department of the New York, Lake Erie and Western Railroad. Resigned in 1885 and commenced practice as Consulting Engineer, New York, as such have had charge of much heavy engineering construction. At present Chief Engineer Rapid Transit Commission, New York City.

PAYNE, CLARENCE QUINTARD, E. M., ... 1882.
President Payne Separator Co., 9 Cliff Street, New York City, and Stamford, Conn.

PEARIS, CHARLES FOWLER, E. M., ... 1884.
Box 374, Helena, Mont.

PECK, STAUNTON BLOODGOOD, C. E., E. M., . . . 1886.
Link Belt Machinery Co., Thirty-ninth Street and Stewart Avenue, Chicago, Ill., and 111 East Thirty-fourth Street, New York City.
One and a half years Mechanical Engineer, Burr & Dodge, Philadelphia. Two years Assistant Chief Engineer Link Belt Engineering Company, Philadelphia. Since 1888, Assistant Chief Engineer Dodge Coal Storage Company. Since 1890 and at present, Chief Engineer Link Belt Machinery Company, Chicago. Specialty, handling materials in bulk or package and power transmissions.

PEELE, ROBERT, E. M., ... 1883.
"The Monterey," One Hundred and Fourteenth Street, and Morning Side Park, New York City.
1883, Assayer, Desgnolle Reduction Works, Charlotte, North Carolina. 1883-84, Assayer and Assistant Sup't Silver-King Mining and Milling Co., Montezuma, Colorado. 1884–86, Foreman, Dry-crushing and Amalgamating Silver-mill, Silver-King Mining Co., Pinal, Arizona. 1886, went to England to examine systems of Sewage disposal used in inland towns. 1887, Professional work as assistant, in New York and Arizona. 1888, Examining gold-mines in Republic of Colombia, S. A. Supt. Mudsill Mining Co., Ltd., Fairplay, Colorado. Examinations and Ore-testing on Copper and Tin Properties, New Mexico and North Carolina. 1889, Examining Gold placers, Dutch Guiana, South America. 1889–90, Supt. Oregon Gold-mining Co., Cornucopia, Oregon. 1890–92, Examining Silver-, Tin-, and Gold-mines in Peru, Bolivia, and Republic of Colombia, S. A., for the Peruvian Exploration Syndicate, Ltd., London, and Lima, Peru. 1892, Adjunct Prof. of Mining, School of Mines, Columbia College.

PELLEW, CHARLES ERNEST, E. M., ... 1884.
College Physicians and Surgeons, 437 West Fifty-ninth Street, and 68 East Fifty-fourth Street, New York City.
1884–85, studied chemistry at Lehigh University and Bethlehem Steel Works. 1885–87, studied chemistry, physics, microscopy and bacteria at School of Mines and at College Physicians and Surgeons. Private Assistant to Professor Chandler. 1887 to date, Instructor and, later, Demonstrator in Physics and Chemistry at College Physicians and Surgeons. Hon. Fellow in Applied Chemistry, School of

Mines. Also in general Chemical practice with professor Chandler as (partner). Specialty, chemical and other expert work, including medical and sanitary questions, *e. g.*, toxicology. Also as patent expert in chemical and physical subjects.

PENGNET, CHARLES PAUL, C. E., ... 1895.
231 West Forty-fifth Street, New York City, N. Y.

PENNINGTON, JOSEPH POPE, A. M. (Associate), . . 1868.
Morristown, N. J.

Assistant Engineer E. T. V. & G. R.R. 1881–83, Engineer Tombstone Mill and Mining Co. 1883–84, 1885 *et. seq.*, railroad construction with general contractors. Assistant Secretary, Louisville, St. Louis and Texas Railway. Resigned August, 1893. Previous responsibilities in connection with life insurance interests.

PERRINE, GEORGE, PH. B., ... 1894.
716 West End Avenue, New York City, N. Y.

PERKINS, THOMAS SLADE, PH. B., ... 1888.
Ninth Street and Gowanus Canal, South Brooklyn, and 39 Garden Place, Brooklyn, N. Y.

1889 to date, New York Tartar Company.

PIERCE, FREDERICK EMERY, C. E., ... 1892.
Address Unknown.

Learner in Bessemer Mill, Maryland Steel Co., Sparrow's Pt., Maryland. Draughtsman, New Jersey Steel and Iron Co., Cooper, Hewitt & Co., New York City. Superintendent of Works Newark Gas Light Co., Newark, N. J.

PIEZ, CHARLES, E. M., ... 1889.
Chief Engineer Link Belt Engineering Co., Nicetown, Philadelphia, Pa.

1889–91, Draftsman with the L. B. E. Co. 1891–92, Assistant Chief Engineer L. B. E. Co. Since 1892 Chief Engineer of the L. B. E. Co., and the Dodge Coal Storage Company, Philadelphia.

PINKHAM, HERBERT, C. E., ... 1885.
176 W. 81st Street, New York City.

PISTOR, WILLIAM, E. M., ... 1868.
Architect, No. 1 Madison Avenue, New York City.

PITKIN, LUCIUS, A. B. PH. B., ... 1881.
138 Pearl Street, New York City.

1881–85, Chemist to Laurel Hill Chemical Works, of Nichols Chemical Company, heavy chemicals, especially sulphuric acid. 1885 to date, Analytical and consulting Chemist, at above address. Specialty in consulting. Manufacture of acids and heavy chemicals, treatment of pyrites and copper smelting. Analytical work. General but special experience in argentiferous and auriferous copper-ores and products. Microscopical and experimental investigations.

POLLEDO, YSIDOSO YGNACIO, E. M., ... 1885.
Apartado 167, Matanzas, Cuba.

1885, Assistant Engineer, Survey for Water-Works for city of Santiago de Cuba. 1886–89, Assistant Engineer and Principal Assistant Engineer in charge of track and structures, Cárdenas and Júcuro R.R., Cárdenas. 1889–90, Manager of Santa Barbara Sugar Plantation, Baró. 1894–95, General Manager Cárdenas Sugar Refinery, Cárdenas.

PORTER, H. HOBARN, JR., E. M., ... 1836.
Westinghouse Electric and Mfg. Co., 120 Broadway, New York City, and Lawrence, L. I., N. Y.

1886–87, Fellow in Geology, School of Mines, Columbia College. 1887–88, Surveyor and Assayer Mexican Ore Company, Sierra Mojada, Mexico. 1888–89, Assistant Mining Engineer Batopilas Mining Company, Batopilas, Mexico. 1889–90, Surveyor and Assayer, Duquesne Mining Co; Assistant Superintendent, Ray & Poorman mine examinations, same company; Assistant Superintendent Sierrita County, Arizona, same company. 1890–91. Engineer with C. W. Hunt Company. 1891, to date, Westinghouse Electric and Mfg. Co.

PORTER, JOHN BONSALL, E. M., PH. D., . . . 1882.
Chemical Engineer Proctor-Gamble Co., Ivorydale, Ohio, and Glendale, Hamilton County, Ohio.

Assistant Engineer and Expert in tests of metals for various railways and corporations. Lecturer of Mechanical Engineering and Metallurgy in University of Cincinnati for some years. At present and for several years past, Engineer Maintenance of way, C. H. & D. R.R. system. Headquarters, Cincinnati, O. Chemical Engineer Proctor-Gamble Co., Ivorydale, Ohio.

POST, ABRAM SKIDMORE, C. E., ... 1884.
173 Madison Avenue, New York City.

POST, ALBERTSON VAN ZO, C. E., ... 1889.
45 Wall Street, and 4 East Sixty-second Street, New York City.

1889–90, Division Engineer, construction, Baltimore and Eastern Shore Railroad. 1881 to date, with the Railroad Equipment Company, of 45 Wall Street, New York City.

POTTER, WILLIAM BLEECKER, A. B., E. M., . . . 1869.
Consulting Mining Engineer, 1225–1227 Spruce St., St. Louis, Mo.

Professor Metallurgy and Mineralogy, Washington University, St. Louis, Mo., to 1893.

POWELL, FREDERICK, A. B., E, M., ... 1883.
Supt. Yorkville Gold Mining Co., Rockinart, Polk Co., Ga.

1883–84, Mechanical Draughtsman and Engineer. 1885, Assayer at Duluth, Examination and Reports on Mineral Deposits in northeastern Minnesota and Canada, Assayer and Manager for Sentinel Gold Mining Co. of Minneapolis and Colorado. 1886 to 1888, Superintendent and Manager in Colorado for Denbigh Mining Co. of New York. 1888-92, Miscellaneous Surveying. 1893, Engineer for Charlotte Mineral and Mining Co., Charlotte, N. C. Examining and Reporting on Mines in North Carolina. June, 1894, to date, Mining Engineer, Charlotte, N. C.

POWERS, LEWIS J., JR., E. M., ... 1884.
Connecticut River Paper Company, Holyoke, and 4 Mattoon Street, Springfield, Mass.

1885, Superintendent Vermont Construction Company, St. Albans, Vt. 1886, Superintendent Standard Pulp Company, Springfield, Mass. 1887–88, Assistant Superintendent Union Paper Manufacturing Company, Holyoke, Mass. 1888 to date, Agent Connecticut River Paper Company, Holyoke, Mass.

PRESTON, WILLIAM EVAN, C. E., ... 1889.
980 Trinity Avenue, New York City.

1889 to date, submarine blasting and dredging for U. S. harbor work with grapple, divers and centrifugal pump.

PROVOST, ANDREW JACKSON, JR., C. E., . . . 1889.
Municipal Building, and 401 Washington Avenue, Brooklyn, N. Y.

1889 to 1894, Assistant Engineer in Sewage Construction, Department City Works, Brooklyn, N. Y. 1894–1896, Engineer in charge Sewerage design, Dept. City Works, Brooklyn, New York.

R.

RANDOLPH, JOHN COOPER F., A. B., A. M., E. M., . 1869.
Consulting Mining Engineer, Mills Buildiug, 15 Broad and 35 Wall Street, New York City, and 18 Elm Street, Morristown, N. J.

Graduated: Princeton, 1866, and School of Mines, New York City, 1869. 1869–71, in Germany, service of U. S. Government. 1874, in service Japanese Government. 1884, in Central China for a Chinese Syndicate. 1887, Resident Manager of La Plata Mines, Republic of Colombia, S. A.; National Commissioner of Mines for Tolima, Republic of Colombia, S. A. 1890, Resident Manager in Borneo of Borneo Diamond Exploration Syndicate, Ltd. For 23 years actively engaged in Professional Work in the United States, Mexico, etc. At different times Members of Council and Vice-President of the American Institute of Mining Engineers. 1891, sick. 1892, all the year in Mexico and Colorado. 1893, in Sonora and Virginia, and various other mining matters in different parts of the country.

RANDOLPH, JAMES FITZ, B. S., E. M., ... 1876.
Communipaw Coal Co., 111 Broadway, New York City.

RAYMOND, ROBERT MATTHEW, A. B., E. M., . . . 1889.
Harqua Hala Gold Mining Co., Harqua Hala, Ariz.

1880–82, Assistant Assayer, State of Maine Assay Office, Portland, Me. 1882–86, Assayer and Assistant Superintendent, Haile Gold Mine, S. C. 1886–89, School of Mines. 1889–90, Assayer and afterwards Assistant Superintendent, Montana Smelting Co., Great Falls, Mont. 1891, Superintendent, The Diamond Mining Co., Neihart, Mont. 1894, General Manager Harqua Hala Gold Mining Co., Harqua Hala, Ariz.

RAYNOR, RUSSELL, PH. B., ... 1889.
Criminal Court Building, and 114 E. Forty-fifth Street, New York City.

Sept., 1889, to Aug., 1891, Chemist, with Martin Kalbfleisch Sons Co. Sept., 1891, to April, 1892, Assistant Chemist, Barber Asphalt Co. May, 1892, to date, Assistant Chemist New York Health Department.

RECKHART, DANIEL WILLIAM, E. M. (Life Member). . 1884.
Reckhardt & Heckelman, Assayers, Box 88, El Paso. Texas.

RECKHART, GEORGE FREDERICK, C. E., ... 1892.
Manager, The Furners & Lewis Co., Apartado No. 23, Pachuca, Estado de Hidalgo, Mexico.

Member of "Southwestern Mining Association" (Incorporated). Surveyor and Assayer for Cia Minera La Aventurera, Sabinal, Estado de Chihuahua, Mexico, since September, 1894. From February, 1894, to August, 1894, was on Engineering Staff of South Shore Railroad Co., Ltd., of Nova Scotia, Canada.

REED, SYLVANUS ALBERT, A. B., A. M., E. M., Life Member), ... 1875,
Manager Tariff Association of New York (Fire Underwriters), 32 Nassau Street, New York City.

1878, Secretary to Assistant Commissioner General, Paris Exposition. 1879, Lectured on Chemistry. Reported on Mines in Colorado. 1880–84, Superintendent and part Proprietor, Sampling and Concentration Works in Colorado, and Reported on Mines there and in Idaho and in the South. 1886, Consulting Practice in New York, Patent Expert work and on Dredging in New York Harbor. 1886–91, Superintendent Inspection Department of Fire Insurance Co. (Commonwealth, of New York). 1893, Expert for New Insurance Rating, Mercantile Section of Boston. May, 1893, appointed Manager Western Factory Insurance Association. Special Agent Western Department of Continental Insurance Co. 1894, Manager Tariff Association Fire Underwriters, New York City.

REES, JOHN KROM., A. B., A. M., E. M., PH. D. (Life Member), ... 1875.
Professor of Astronomy and Director of Observatory, Columbia College, and 1 W. Seventy-second Street, New York City.

A. B., Columbia College, 1872. Fellow in Science, 1872–75. A. M., 1875. E. M., 1875. Assistant in Mathematics, School of Mines, 1873–76. Professor of Mathematics and Astronomy, Washington University, St. Louis, Mo., 1876–81. Director of the Observatory, Columbia College, 1881. Instructor in Geodesy and Practical Astronomy, Columbia College, 1881–82. Professor of Astronomy, 1892. Chairman Board of Editors, SCHOOL OF MINES QUARTERLY, 1883–90. Vice-President New York Mathematical Society, 1891. Chairman of Section on Astronomy and Physics of New York Academy of Sciences, 1891. Secretary of American Metrological Socisty, 1882. Fellow of Royal Astronomical Society of London, 1892. Member of the Astronomishe Gesellschaft, 1893. President of New York Academy of Sciences, 1894–95. Chairman Section on Astronomy and Physics of N. Y. A. S., 1891–94. Sec. Y. Am. Met. Soc., 1882. President N. Y. A. Sci., 1894–96.

RENAULT, GEORGE, C. E., ... 1883.
122 E. Nineteenth Street, New York City.

RESTREPO, CAMILO CLAUDIO, E. M., C. E., . . - 1887.
Medellin, Republic of Colombia, S. A.

RHODEL, FRANCIS BELL FORSYTH, E. M., . . . 1874.
National S. & R. Co., South Chicago, Ill., and Quebec, Canada.
May, 1875, to December, 1876, Surveying Corps, Coxe Bros., Drifton, Pa. January, 1877, to May, 1878, Assistant Superintendent, South American Mining Co., Venezuela. November, 1878, to June, 1879, Working at Lead Mine, Canada. October, 1879, to April, 1880, Laborer, Ontario Mill, Park City, Utah. April, 1880, to July, 1881, Assistant Superintendent, Minge Furnace Co., Utah. August, 1881, to January, 1882, Assistant Superintendent St. Helena Mine, Sonora, Mexico. January, 1882, to April, 1883, Assistant Superintendent, Tombstone, M. and M. Co., Arizona. May, 1883, to December, 1883, Superintendent, Ramsham Smelting Furnace, Idaho. January, 1884, to May, 1885, Assistant Superintendent, Minge Furnace Co., Utah. June, 1885, to December, 1885, Foreman of Blast-furnace Department, Kansas City S. and R. Co. October, 1886, to December, 1889, Superintendent, Chicago Works, Chicago and Aurora S. and R. Co. January, 1890, to date, Superintendent National S. and R. Co., South Chicago.

RHODES, ROBERT DUNN, E. M., ... 1879.
Arkansas Valley Smelting Works, Leadville, Col., and Box 726, Quebec, Canada.
1879–80, Foreman, Germania Smelting Co., Salt Lake City. 1880–82, Night Foreman, Ontario Silver Mining Co., Park City, Utah. 1882–83, Superintendent, Tombstone M. and M. Co. Reduction Works, Charleston. 1883–84, Mill Foreman, St. Helena Gold and Silver Mine, Sonora. 1884–85, Assistant Superintendent, Billing Smelter, New Mexico. 1885–86, Assistant Superintendent, Viola M. and S. Co., Idaho. 1887–88, Assistant Superintendent, Anglo-Mexican Mining Co., Yedras, Mexico. 1889–91, General Superintendent, Duquesne M. and R. Co., and Sierrita County, Arizona. 1891–92, Engineer Fraser and Chalmers, City of Mexico. 1892–94, Supt. as above.

RICE, GEORGE SAMUEL, JR., E. M., ... 1887.
119 S. Market Street, and 432 N. Court Street, Ottumwa, Iowa.
1887, Assistant Field Engineer, Colorado & Utah Railway. 1888–89, Assistant Mining Engineer of Colorado Fuel Co. 1890 to date, Mining Engineer of Whitebreast Fuel Co.

RICH, JACOB MONROE, E. M., C. E. (Life Member) . 1883.
50 W. Thirty-eighth Street, New York City.
Pursuing further studies since graduation.

RICHARDSON, JOHN CLARENCE, E. M., C. E., . . . 1883.
Address unknown.

RICKETTS, PIERRE DE PEYSTER, E. M., PH. D., . . 1871.
Professor, Analytical Chemistry, Columbia College School of Mines, and 115 E. Seventy-ninth Street, New York City.
1868, Assistant, General Chemistry, Columbia College. 1871–72, Assistant in Mineralogy and Metallurgy, School of Mines. 1872–75, Assistant in Assaying, School of Mines. 1875–86, Instructor in Assaying, School of Mines. 1886 to

to date, Professor of Assaying, School of Mines. Since graduation also engaged in general Metallurgical, Chemical and Mining Engineering work.

RIDSDALE, THOMAS WEDDLE, E. M., ... 1883.
Ridsdale & Lewis, 39–41 Cortlandt Street, New York City.

Assistant Superintendent of the Ruby Durango Mine, and Wilder-Macdonald Concentrating Mill to 1884. Superintendent of the Wilder-Macdonald Mill, 1884. From 1888 with the Worthington Pumping Engine Co. From June, 1889, as Secretary of the Company.

RIES, HEINRICH, PH. B., ... 1892.
Mineralogical Department, School of Mines, Columbia College, and 28 W. 128th Street, New York City.

Summer of 1891 and 1892, on New York Geological Survey. October, 1892, to August 1, 1893, Assistant Director, New York Scientific Exhibit at World's Fair. July 1, 1893, to July 1, 1894, Fellow in Mineralogy, Columbia College.

ROESER, FREDERICK, B. S., E. M., ... 1884.
240 West 130th Street, New York City.

ROGERS, OSCAR LEGARE, PH. B. (Arch.), . . . 1889.
27 West Eighty-second Street, New York City.

1889–92, in Europe. 1893, Architect. 1894, in Europe.

ROLKER, CHARLES M., E. M. (Life Member), . . 1875.
Mills Building, New York City.

1868–70, At Royal School of Mines, Clausthal, Germany. 1871–72, Working practically in Iron Mines of Hibernia and Mt. Pleasant, N. J., Wisconsin Lead Mines and Iron Mines of Lake Superior. 1872-75, At School of Mines, Columbia College. 1876, Assayer at Allouez Copper-dressing Works, Lake Superior. 1877, Mining Engineer to the Mariposo Land and Mining Co., Mariposa, Co., Cal. (Gold). 1878, Superintendent, Brooklyn Company, Washoe Co., Nevada (Base Metal). 1879, Superintendent, Stormont Silver Co., Silver Reef (Silver). 1880–82, General Manager, Chrysolite S. Mfg. Co., Leadville, Colo. (Lead Carbonates). Since then to date, in General Consulting Practice as Mining Engineer and Metallurgist, Examining Mines, Mills and Placers, in the United States, Old Mexico, Central America, South America and East Indies. Specialty, Precious and Base Metals other than Iron. 1891-92, Cons. Engr. to the British South African Company in its sphere south of Zambesi. 1894, Practicing, Consulting Mining Engineer.

ROOD, ROLAND GOUVERNEUR, PH. B., ... 1884.
Care Prof. O. N. Rood, Columbia College, New York City.

ROSENTHAL, ALBERT, C. E., ... 1892.
158 East Seventy-ninth Street, New York City.

ROWLAND, CHARLES BRADLEY, C. E., ... 1884.
Continental Iron Works, Greenpoint, Brooklyn, N. Y., and 329 Madison Avenue New York City.

ROWLAND, GEORGE, C. E., ... 1887.
Continental Iron Works, Greenpoint, Brooklyn, N. Y., and 329 Madison Avenue, New York City.

RUPP, PHILIP, PH. B., M. D., ... 1884.
334 East 17th Street, New York City.
1884–87, Student of Medicine, College of Physicians and Surgeons, N. Y. 1887-88, House Physician and House Surgeon, St. Francis Hospital, N. Y. 1888 to date, Practicing Physician.

RUTHERFORD, F. M., E. M., ... 1879.
46 East 64th Street, New York City, N. Y.

RUTTMANN, FERDINAND, JR., E. M., ... 1880.
35 Broadway, New York City.

RYON, AUGUSTUS MEADER, E. M., ... 1886.
Prof. Engineering, College of Agriculture and Mechanic Arts, Bozeman, Montana.
1886–87, Assistant Engineer on New London Water Works. Assistant in Metallurgy, School of Mines, Columbia College. 1887–88, Assistant to F. N. Owen, Civil and Sanitary Engineer, New York City. 1888–91, Professor of Engineering and Mining, School of Mines, College of Montana, Deer Lodge, Mont. 1892 to date, President and Professor of Engineering, Montana College of Agriculture and Mechanical Arts, Bozeman, Montana. 1894, Irrigation Engineering for Agricultural Experiment Station.

S.

SAGE, EDWARD EUGENE, C. E. (Life Member), . . 1877.
United States Assay Office, 30 Wall Street, New York City, and 77 Hillside Avenue, Orange, N. J.
I have been connected with this office since February, 1879, and have consequently no outside experience except in electricity, being President of the Essex County Electric Co., of Orange, N. J., and in Analytical Chemistry.

SANDS, FERDINAND, A. B., PH. B., ... 1882.
Drugs and Assaying Supplies, Box 1172, Butte, Mont.

SCHERMERHORN, FREDERICK AUGUSTUS, E. M. (Life Member), ... 1868.
41 Liberty Street, and 61 University Place, New York City.

SCHIEFFELIN, WILLIAM JAY, PH. B., PH. D. (Munich), . 1887.
Schieffelin & Co., 170 William Street, and 35 West Fifty-seventh Street, New York City.

SCHNEIDER, ALBERT FRANCIS, E. M., C. E. (Life Member), ... 1876.
Perth, Amboy, N. J.

1876–77, In Europe visiting Smelting and Dressing Works. 1878, Chemist and Assayer Germania S. and R. Co., Salt Lake City, Utah. 1879, Foreman, Assistant and Superintendent Germania S. and R. Co., Salt Lake City. 1880–'83, Superintendent Germania S. and R. Co., Salt Lake City, Utah. 1883–'85, Superintendent G. Billing Smelting Works, Socorro, N. M. 1885–87, Superintendent Kansas City S. and R. Co., Argentine, Kansas. 1887, Connected with the Rio Grande S. Co., Socorro, N. M. 1887 to 1893, General Manager St. Louis S. and R. Co., St. Louis, Mo. Superintendent Great National Smelting Co., Monterey, Mexico, 1895.

SCHROEDER, J. LANGDON, C. E., ... 1889.
Member of firm of Parrish & Schroeder, Architects, 1 Madison Avenue, and 27 E. Thirty-first Street, New York City.

July, 1890, to January, 1894, with Renwick, Aspenwall & Renwick, New York City, as Architectural Draughtsman.

SCHROTER, GEORGE AUSTIN, E. M., ... 1893.
Box 877 Denver, Colo.

Superintendent Keystone and Manager Logan Group Mines, Colorada. Chemist Denver White Lead Works, February–August, 1894. Supt. of Rico Smelting and Ref. Co., Rico, Colorada, June, '93, to December, '95.

SCHUMANN, CHARLES HENRY, C. E., ... 1888.
Small & Schumann, 265 Broadway, and 21 East 99th Street, New York City.

1888, May, 1890, Assistant Engineer Chesapeake and Ohio Railway Co., Cincinnati, charge of Real Estate, Right of Way and Track and Construction work. May to August, 1890, Assistant Engineer to H. Alber, C. E., Birmingham, Ala., General Engineering. August, 1890, to March, 1891, Assistant Engineer Chesapeake and Ohio Railway Co., charge of subdivision of Town of West Clifton Forge, Va., and Right of Way on line of road. 1892–93, Assistant Engineer Long Island R. R., and Engineer for Ferris & Richards, Contractors for Railroads and Waterworks, at 98 Hudson street, Jersey City, N. J. 1893–94, with James R. Croes., C. E., Waterworks Supply and Sewerage, 1894. Private practice as Small & Schumann, Architects and Civil Engineers.

SELIGMAN, JOSEPH GUY, E. M., ... 1887.
Mining Superintendent, and 506 W. 143d Street, New York City.

SELDNER, RUDOLPH, PH. B., ... 1894.
Adelphi Academy and 217 Jefferson Avenue, Brooklyn, N. Y.

Instructor in Science Adelphi Academy, 1894 to date.

SELF, E. D., E. M., ... 1894.
South Orange, N. J.

Received degree of Mechanical Engineer at the Stevens Institute of Technology in 1886. Engaged in engineering and construction work. Designing and purchasing machinery for large mills in Australia and Mexico. Report on transmission of power project for mining plant in Mexico. Examination of mines in South America. Superintendent of mine in Guyana, South America. Received degree of Engineer of Mines from Columbia College in 1994. Instructor in Min-

ing at Lake Superior for class in practical mining. At present Supt. and Manager of the Sonora Copper Co., Sonora, Mexico. Received patent for system of ore concentration.

SEWARD, JOHN, E. M., ... 1895.
97 Cedar St., New York City, and 416 Main Street, Orange, N. J.

SHARE, WILLIAM WALDEMAR, PH. B., PH. D., . . 1881.
Adelphi Academy, and 331 McDonough Street, Brooklyn, N. Y.
1881, Superintendent Columbia Chemical Works, Brooklyn, N. Y. 1881–88, Assistant Physics, Columbia College. 1888, Consulting Electrician, Department of Public Parks, Brooklyn, N. Y. 1889 to date, Professor of Chemistry, Adelphi Acadamy, Brooklyn, N. Y.

SHATTUCK, L. R., B. S., C. E., ... 1895.
138 Eighth Avenue, Brooklyn, N. Y.

SHERMAN, FRANK DEMPSTER, PH. B., ... 1884.
Adjunct Professor of Architecture, School of Mines, Columbia College, New York City, 312 S. Broadway, Yonkers, N. Y.

SHRIVER, HENRY TOWER, PH. B., ... 1888.
T. Shriver & Co., 333 E. Fifty-sixth Street, and 686 Park Avenue, New York City.
In Iron Foundry and Works, as above, since graduation.

SIMONDS, FRANCIS MAY, E.M., PH. D. . . . 1887.
Assistant in Assaying, Columbia College, School of Mines, and 147 E. Thirty-fourth Street, New York City.

SINGER, GEORGE, JR., E. M., ... 1880.
111 Fourth Avenue, Pittsburgh, Pa.

SINGER, GEORGE HARTON, E. M., ... 1880.
Singer, Nimick & Co., and 17 Park Street, Allegheny, Pa.

SKINNER, ELMER, C. E., ... 1891.
227 Cumberland Street, Brooklyn, N. Y.

SLACK, CHARLES GODDARD, E. M., ... 1884.
328 Fourth Street, Marietta, Ohio.

SLADE, RICHMOND EDWARD, PH. B., ... 1887.
White Plains, N. Y.
1887, Assistant Superintendent United Gas Improvement Co., Yonkers, N. Y., Plants. 1888, Superintendent Gas Department, Ashville (N. C.) Light and Power Co. 1888, Superintendent Gas and Electric Plants, Citizens' Gas Light Co., Jackson, Tenn. December, 1889, to date, Secretary, Superintendent and Trustee Citizens' Gas and Electric Co., White Plains, N. Y.

SMITH, AUGUSTUS, A. B., C. E., ... 1889.
39 Cortland St., and 460 W. Forty-fourth St., New York City.
Summer of 1886, Land Surveying (in charge of Party). July to November,

1889. Draughtsman, Link Belt Engineering Co., Nicetown, Phila. November, 1889–91, Chief Draughtsman, New York Office Link Belt Engineering Co. 1891–92, out of Professional work. 1892, Salesman and Engineer as above. 1893 to date, private practice as Engineer and Contractor.

SMITH, FRANK MARSHALL, E. M., ... 1889.
Supt. United Smelting and Refining Co., Smelter, Cascade Co., Mont.

1889–90, On the United States Geological Survey, engaged in hydrographic work on the Irrigation Survey and triangulation on the Topographic Survey, in Idaho and Oregon. 1891, Assayer Colorado Smelting Co., Pueblo, Colo. October, 1892–93, Assistant Superintendent. 1893 to date, Supt. United Smelting and Refining Co., Smelter, Mont.

SMITH, FRANCIS PITT, PH. B., ... 1888.
Care Harrison BROS. Co., 35 Gray's Ferry Road, Philadelphia, and Sedgwick Avenue and Main Street. Germantown, Philadelphia, Pa.

Analytical Chemist in Leather trade, 1888–89. Superintendent Chemical Works, Wm. H. Swift & Co., East Boston, Mass., 1889–90. Consulting Chemist, Dening & Logan, 58 William Street, 1890. Assistant Chemist New York City Health Department, 42 Bleecker Street, 1890–92. Specialty, Chemical Mechanics. 1892–93, Inspection Brooklyn Navy Yard. 1896 with Harrison Bros. & Co., Phila., Pa.

SMITH, LENOX, A. B., A. M., E. M. (Life Member), . 1868.
120 Broadway, New York City.

SMITH, WILSON FITCH, C. E., ... 1894.
Room 409, Spalding Bldg., 31 W. 42d St., New York City.

1895, Engineering Department, N. Y. C. & H. R. Ry.

SMITH, WILLIAM ALLEN, E. M., ... 1868.
52 Wall Street, and 102 East Fifty-seventh Street, New York City.

SMYTH, CHARLES HENRY, JR. PH. B., PH. D., . . 1888.
Professor of Geology, Hamilton College, Clinton, N. Y.

1888-89, Chemist Franklin Iron Mfg. Co. 1889–90, Geological Field Work in New York, Alabama, Georgia, and Tennessee. June, 1890, received Degree of Doctor of Philosophy from Columbia College. 1889–91, studied Petrography and Mineralogy with Prof. Rosenbusch at the University of Heidelberg. 1891, appointed Professor of Geology in Hamilton College. Engaged in the study of the Western Adirondack region, and the investigation of Problems in Central New York. Chiefly in Petrographic, Chemical and Glacial Geology. Asst. on N. Y. Geol. Survey, 1893–95.

SNOOK, THOMAS EDWARD, E. M., ... 1884.
Architect, 261 Broadway, New York City.

1884–87, Supt. Cons. for John B. Snook, Architect. 1887 to date, Member of the firm of and Chief Engineer for John B. Snook & Son, Architects.

SOUTHARD, GEORGE CARROLL, C. E., ... 1892.

66 Beaver Street, New York City, and 111 Montague Street, Brooklyn, N. Y.

June, 1892, to March, 1893, Equity Gas-Works Construction Co., Brooklyn, E. D. March, 1893, to January, 1894, with Heine Safety Boiler Co. January, 1894–95, with Hecker-Jones-Jewell Milling Co. From Aug., 1895, to date, with Southern Pine Co., of Ga.

SPOONER, ALLET, NAWHALL, C. E., ... 1886.

Department of Docks, Pier A, North River, New York City, and 186 Carteret Avenue, Jersey City, N. J.

July, 1886 to August, 1887, Rodman and Draughtsman, Penn. R. R., Jersey City. August, 1887, to May, 1890, Hydrographer Department Docks, New York, City. May, 1890–91, to present time, Assistant Engineer Department Docks, New York City. Specialty, Railroad Engineering, River, Submarine and Harbor Engineering.

STANTON, FRANK MCMILLAN, E. M., ... 1887.

Superintendent Atlantic Mine, Houghton Co., Mich.

1887–88, Superintendent pro tem. Central Mine, Mich. 1888–89, Engineer Atlantic Mine, Mich. 1889 to date, Superintendent Altantic Mine, Mich.

STAREK, EMIL, LL. B., LL. M., E. M., . . . 1895.

Keller & Starek, Patents, 703 Commercial Building, and 4204 A, Cook Avenue, St. Louis, Mo.

1885–87, Assistant in United States Geological Survey, 1887–92, Assistant Examiner United States Patent Office, Washington, D. C.

STARR, CHANDLER DANNAT, C. E., ... 1881.

Address unknown.

STAUNTON, WILLIAM FIELD, E. M., ... 1882.

Superintendent of the Congress Gold and Mining Co., Congress, Ariz.

1882, Assayer and Assistant Superintendent Vermont Copper Co., Ely, Vt. 1882, Assayer and Accountant Dunn Mt. Gold Mine, Salisbury, N. C. 1883, Assayer Ledoux & Ricketts, N. Y. 1883, Constructing Engineer, C. M. and R. Co., N. Y. 1883, Assistant to Manager of Mills and Smelting of T. M. and M. Co., Tombstone, Arizona. 1884, Consulting Engineer, N. Y. 1884, Mining Engineer for T. M. & M. Co., Tombstone, Arizona. 1890, to date, Superintendent Tombstone Mill and Mining Co., Tombstone, Ariz., and 1894, Superintendent Congress Gold Mining Co., Congress, Ariz. Specialty, Gold and Silver Mining and Metallurgy.

STEARNS, THOMAS BEALE, E. M., ... 1881.

Care The Stearnes-Roger Mfg. Co., Mining Machinery, Denver, Colo.

STEWART, JOHN HENRY, C. E., ... 1895.

Dept. of Building, 18th Street and 4th Avenue, and 123 West 11th Street, New York City.

STONE, GEORGE CAMERON, PH. B., PH. D., ... 1879.

New Jersey Zinc and Iron Company, Newark, N. J.

1879, Chemist, Booth & Edgar Sugar Refinery. 1879–82, Chemist with Potter & Riggs, St. Louis, Mo. 1882–91, with New Jersey Zinc and Iron Company, Newark, N. J., first as Chemist; since 1884, as Superintendent Blast-Furnaces. May, 1894, to date, Superintendent of company.

STRUTHERS, JOSEPH, PH. B., PH. D., ... 1885.

Tutor in Metallurgy, Columbia College, School of Mines, and 624 East One Hundred and Thirty-sixth Street, New York City.

1885–88, Fellow in Mineralogy. 1888–90, Assistant in Mineralogy and Metallurgy. 1891 to date, Tutor in Metallurgy Columbia College, School of Mines. 1893–94, Delivered the lectures in Metallurgy at the School of Mines in place of Dr. Egleston, who was absent on account of sickness. Summer of 1894, spent in Europe in the study of metallurgical works and processes. 1894–95, Special work upon pyrometers and calorimeters. Specialty, The measurements of high temperatures and the physical properties of slags.

STUART, WILLIAM HENRY, C. E., ... 1886.

36 West Seventieth Street, New York City.

1886, on Railway Surveys in Minnesota and Wisconsin with C B. & N. R. R. Co. 1887–89, Fellow in Engineering and Assistant in Summer School of Surveying, School of Mines, Columbia College. 1889–90, making surveys and superintending construction at the Hudson River State Hospital, Poughkeepsie, N. J. 1890, on surveys in the West Indies. 1893, in general practice.

SUTER, GEORGE AUGUSTUS, E. M., ... 1883.

G. A. Suter & Co., Engineers and Contractors, 411 West Broadway, New York City, and 78 Locust Ave., New Rochelle, N. Y.

1884–92, Engineer, Baker, Smith & Co. 1892 to 1896 with G. A. Suter & Co.

SWAIN, ALFRED ERNEST, E. M., ... 1881.

Supt. Trinidad Mining Co., Copala, (via Mazatlan, Sinaloa, Mexico), and 902 Prospect Street, Cleveland, O.

1881–84, railroad work in Mexico. 1885–88, City Engineer's Department, Kansas City, Mo., in charge of sewer work. 1889–91, mining work in Mexico. 1891, Supt. San Buenaventura Mining Company, Santa Lucia, Sinaloa, Mexico. via Mazatlan and Pana. 1891–93, Supt. Trinidad Mining Co.

T.

TAINTOR, WILLIAM NOYES, PH. B., ... 1894.

60 West Forty-eighth Street, New York City.

August, 1894, to September, 1894, Levelman, Metropolitan Traction Co. September, 1894, to date, Transitman, Ramapo Water Co.

TAYLOR, JOSEPH B., E. M., ... 1888.

56 and 58 Pine Street, New York City, and 404 Seneca Street, Brooklyn, N. Y.

1888–90, Practical shop work. 1890–94, Daughtsman and Asst. Supt. Columbian Iron Works, Brooklyn. 1894 to date, general practice mechanical engineering.

TEMPLE, SETH JUSTICE, PH. B., ... 1892.
Cure Sebastin Reali, Rome, Italy.
Instructor in Architectural Drawing Art Schools of the Metropolitan Museum of Art, Fifth Ave. and Thirty-Second Street, New York City.

TERHUNE, RICHARD HENRY, E. M., ... 1870.
Salt Lake City, Utah.
1870, Assistant to late J. W. Foster, geology of coal fields, Indiana. 1871, Griswold Steel Works, draughting, blowing steel, etc. 1872–77, Joliet Steel Company, draughting, inspecting steel rails and exploration of Callaway County, Missouri, for coal and iron. 1877–80, Superintendent and Assistant Superintendent Smelting Works in Utah. 1880–93, General Superintendent Hanauer Smelting Works, Utah. Specialty, construction and operation of lead smelting works. Resigned above position September, 1893. 1894, Examining and Reporting on Mines and Works.

THACHER, ARTHUR, C. E., E. M., ... 1877.
4109 Washington Avenue, St. Louis, Mo.
1878–79, with Progreso Mining Company, Trimfo, Lower California, Mexico. 1879–83, Southern Arizona and Northern Mexico Mining and Milling. 1883–87, office in New York. Examining and reporting on mines and mills. 1887 to date, with Professor W. B. Potter, at St. Louis Sampling and Testing Works and Washington University. Lecturing on Metallurgy. Testing ores, etc. Examining and reporting on mines and mills. Superintendent Central Lead Co.

THOMAS, FREDERICK MAYHEW, E. M., ... 1885.
20 City Hall, Syracuse, N. Y., and Box 204, Skaneateles, N. Y.
Leveller (Instrument man, etc.), on New York State Canals, from September, 1887, to November, 1889 (position resigned). Transitman and leveller on preliminary railroad survey in Schoharie County in spring of 1890. Transitman and leveller on Syracuse Water Works during the winter of 1890–91.

THOMPSON, HENRY CLARK, C. E., ... 1886.
Lorillard Place, and One Hundred and Eighty-seventh and One Hundred and Eighty-eighth Streets, New York City.

TIBBALS, GEORGE ATWATER, C. E., ... 1883.
Continental Iron Works, and 148 Milton Street, Brooklyn, N. Y.
1883 to date, as above.

TIBBALS, SAMUEL GAYLORD, C. E., ... 1884.
Continental Iron Works, and 148 Milton Street, Brooklyn, N. Y.
1884 to date, as above.

TILDEN, GEORGE CYRUS, C. E., ... 1876.
State School of Mines, Golden, Colo.
1876–80, City Surveyor, Brooklyn, N. Y. 1880–81, Superintendent Dunderberg Mining Company, Georgetown, Colo. 1881–82, Chemist and Assayor, Denver, Colo. 1882 to date, Professor Analytical Chemistry State School of Mines, Golden, Colo. 1881 to date, Consulting Practice as Mining Engineer. Specialty Analytical Chemistry and Assaying.

TITUS, WARREN HARRIOTT, E. M., ... 1885.
Sanitary Engineer, Lincoln Building, 1 Union Square, New York City, N. Y., 220 Fourth Avenue and 80 E. Washington Square, New York City, and Whitestone, N. Y.

1885–86, Post Graduate Course in Civil Engineering School of Mines and traveling in Europe. From 1886–92 in the Board of Health employed as follows: From Oct. 1886–87 Assistant Sanitary Engineer and Inspector of Plumbing. From 1887–88 Assistant Sanitary Engineer and Special Inspector of Plumbing, Drainage, Light and Ventilation. From 1888, to Nov., 1890, Assistant Sanitary Engineer and Special Inspector and Examiner of Plans for Plumbing, Drainage, Light and Ventilation. From Nov., 1890, to June, 1892, Assistant Chief Inspector of the Division of Plumbing, Drainage, Light and Ventilation. From Dec., 1891, to June, 1892, Acting Chief Inspector in charge of Division of Plumbing, Drainage, Light and Ventilation. From June, 1892, to Oct., 1895, Examiner of Plans for Plumbing, Drainage, Light and Ventilation in the Department of Buildings of New York City. 1895, Practicing as Sanitary Engineer, New York City.

TONNELÉ, THEODORE, PH. B., ... 1880.
Care of Wm. Dewees Wood Co., McKeesport, Allegheny Co., Pa.

In charge of Refining and Steel Departments of the William Dewees Wood Company.

TOWER, ALBERT EDWARD, E. M., ... 1883.
Poughkeepsie Iron Company, Poughkeepsie, N. Y.

TOWER, FREDERIC WETHERWAX, E. M., . . . 1887.
Assistant Examiner, Room 223, Patent Office, and 1400 L. Street, N. W., Washington, D. C.

1888 to date, as above.

TRAPHAGEN, FRANK WEISS, PH. B., PH. D., . . 1882.
Chemist in Charge of Chemical Laboratory, Montana College of Agriculture, Bozeman, Mont.

1883–84, Chemist for Williams, Clark & Co., Fertilizers. 1884–87, Instructor in Chemistry and Physics, Staunton Military Academy, Staunton, Va. 1887, Professor of General, Analytical and Applied Chemistry and Assaying in the College of Montana and Montana School of Mines. 1884–87, Analytical and Consulting Chemist, Staunton, Va. 1887, Principal work, fertilizer, iron and steel, clays, etc. Analytical and consulting Chemist and Assayer, Deer Lodge, Mont. Assaying, miscellaneous analysis and legal work. 1890, Assayer for the Champion Consolidated Mining Company, Deer Lodge, Mont. 1892–93, in charge Montana Mining Exhibit at Columbian Exhibition. 1893, Professor Chemistry Montana College of Agriculture and Mech. Arts. 1895, Chemist Montana Agricultural Experiment Station.

TRASK, GEORGE FRANCIS DONNELL, E. M., . . . 1887.
99 Cedar Street, New York City.

1888–90, Apprentice and Machinist, L. & N. Railroad. 1890–91, Draughtsman, L. & N. Railroad, Louisville.

TUSKA, GUSTAVE ROBITSCHER, B. S., M. S., C. E. . 1891.
School of Mines, Columbia College, 41 East Forty-ninth Street, and 55 East Sixty-fifth Street, New York City.

1891–92, Civil and Mechanical Engineer Link-Belt Engineering Co., Philadelphia. 1892–93, Bridge Engineer, Long Island Railroad. Assistant Engineer C. N. Y. and W. R. R., in charge of Stony Brook viaduct, 1893. Consulting Engineer Port-au-Prince Ry., Cuba, 1893 to date. Resident Engineer, Knoxville, Cumberland Gap and Louisville R. R. Co., in charge of Construction of Louisville Viaduct, 1893. Assistant to Professor of Civil Engineering, Columbia College, 1893. Tutor in Civil Engineering, School of Mines, 1894.

TUTTLE, EDGAR GRANGER, E. M., ... 1881.
520 Summer Avenue, Newark, N. J.

1881, Assistant Engineer, Tilly Foster Iron Mine, Brewster, N. Y. 1881–82, Division Engineer, Wheeling & Lake Erie R. R., Toledo, O. 1882–83, Assayer and Mining Engineer, Silver City, New Mexico. 1883–85, Division and Office Engineer, Arizona & New Mexico Railroad, Lordsburg, Arizona. 1885, Constructing Engineer at Mines, Arizona Copper Co., Clifton, Arizona. 1885–89, Mining Engineer, Cambria Iron Co., Johnstown, Pa. 1889–94, Superintendent Alamo Coal Co., and Coahuila Coal Co., San Felipe, Coahuila, Mexico. Box 109, Eagle Pass, Texas. 1894, Examinations in Deap River Coal Field for Egypt Coal Co., North Carolina. 1894, Examination in Pocohontas Field, West Virginia, 1895, Writing "Surface Arrangements of Bituminous Mines," for Correspondence School of Mines, Scranton, Penna. 1895, Expert Examinations of Property and Operations of Columbus & Hocking Coal and Iron Co., Columbus, Ohio, for Bondholders' Committee.

TYLER, WALTER LINCOLN, C. E., ... 1887.
116–120 Front Street, and 1314 Pacific Street, Brooklyn, N. Y.

1887, Levelman and Transitman on the Roanoke & Southern Railroad, Va. 1888, With J. A. Latham, C. E., Providence, R. I. 1888–89, With F. N. Owen, E. M., Sanitary Engineer, New York City. 1889 to the present time, With The A. B. See Manufacturing Co., 116–120 Front Street, Brooklyn.

V.

VAIL, LEWIS H., E. E., ... 1894.
Locust Valley, Long Island, N. Y.

VALUE, BEVERLY REID, E. M., ... 1884.
Address unknown.

VANDERBILT, WILLIAM D., C. E., ... 1894.
39 Monroe Place, Brooklyn, N. Y.

VANDERPOEL, FRANK, E. M., ... 1875.
Chemist, The Celluloid Co., 295 Ferry Street, and 191 Roseville Avenue, Newark, N. J.

1875–78, Salesman, with E. B. Benjamin. 1878 to date, as above.

VAN ARSDALE, WILLIAM HENRY, A. B., A. M., E. M., 1868.
Vice-President Chicago and Aurora Smelting and Refining Co., Chicago, Ill.

VAN BLARCOM, ELBERT CHAMPLIN, C. E., . . . 1876.
Care H. de San Francisco Pachuca, Hidalgo, Mexico.

VAN CORTLANDT, EDWARD NEWENHAM, E. M., . . 1885.
Tuxedo Park, N. Y.

VAN DYCK, EDWIN, PH. B., ... 1888.
1080 Dean Street, Brooklyn, N. Y.

VAN SINDEREN, ALVAN HOWARD, PH. B., . . . 1881.
Attorney and Counselor-at-Law, 15 Broad Street and 29 Washington Square, New York City.

VAN VOLKENBURGH, EDWARD, JR., C. E., . . . 1888.
Morgan & Bartlet, 41 Wall Street, New York City.

VAN WAGENEN, THEODORE FRANCIS, E. M., . . . 1870.
Box 589, Telluride, Colo.
1893, President and General Manager of the Deming Ore Co., Deming, Grant Co., New Mexico. 1894, Consulting Mining Engineer, Denver, Colo. 1896, Muge Flora-Climax Gold Mines, Telluride, Colo.

VOLCKENING, GUSTAV JULIUS, MET. ENG., E. M., . . 1888.
88 Clinton Avenue, Brooklyn, N. Y.

VONDY, RUDOLPH HARRISON, E. M., ... 1882.
305 Montgomery Street, Jersey City, N. J.
1882–83, Assistant Engineer, Tilly Foster Iron Mine. 1885–92, Chemist Phœnix Iron Works, Phœnixville, Pa. 1892, Supt. Plenty Hort'l and Skylight Works.

VON NARDROFF, ERNEST ROBERT, E. M., . . . 1886.
Instructor of Physics, Barnard College, 343 Madison Avenue, New York City, and 89 Quincy Street, Brooklyn, N. Y..

VULTÉ, HERMANN T., PH. B., PH. D. . . . . 1881.
Assistant in Quantitative Analysis, School of Mines, New York City, and New Rochelle, N. Y.
1881–82, Superintendent Columbia Chemical Works, Brooklyn, N. Y. 1883–91, Assistant Instructor in Analytical Chemistry, School of Mines. Engaged in investigating new Analytical Methods. Specialty : Commercial Organic Analysis Expert in Oils, Fats, Soap, etc.

WAINWRIGHT, JOHM HOWARD, PH. B., . . . 1882.
Chemist, 402 Washington Street, New York City.

W.

WALKER, H. V., PH. B., ... 1894.
38–40 Clinton Street, Brooklyn, N. Y.

WALKER, ARTHUR LUCIEN, E. M., ... 1883.
Genl. Mgr. Baltimore Elec. Ref. Co., Keyser Building, Baltimore, Md.

1883–84, Chemist and Assayer, Old Dominion Copper Co., Globe, Arizona. 1885, Assistant Superintendent of same Co. 1886, Engaged in connection with Iron Metallurgy in New York City. 1887, Mechanical Engineer for Silver King Mining Co., Silver King, Arizona. 1888–93, Superintendent, Old Dominion Copper Co., Globe, Arizona. Also report on all classes of Mining and Metallurgical Property in Arizona. 1893–95, Consulting Engineer Old Dominion Copper Co. 1893 to date, General Manager Baltimore Electric Refining Co., Baltimore, Md.

WALLER, ELWYN, A. B., A. M., E. M., PH. D., . . 1870.
7 Franklin Place, Morristown, N. J.

WAMPOLD, LEO, PH. B., ... 1888.
204 Monroe Street, Chicago, Ill.

WARD, DELANCY WALTON, PH. B., ... 1888.
Whitestone, N. Y.

WARNER, JOSEPH LOWERY, E. M., ... 1887.
419 Bailey Building, Seattle, Wash.

August, 1887, to August, 1888, Omaha and Great Smelter, Denver, Assistant Assayer. August, 1888, to July, 1889, Examination of and Reports on Mines in Cœur d'Almes, Idaho and in O'Kanagrn Mining District, Washington. Manager La Bellevue Mine, same district. July, 1889, to January, 1890, Assistant Superintendent and Amalgamator, Golden Monarch Mine, Oregon. January, 1890–92, Examination and Reports on Mines in Western Washington. Manager, Culver Mining Co. and V. P. Vermilion Iron Co. 1892, Examinations in Cascade Range. 1893, Examinations of Iron Deposits, Island of Texado, British Columbia.

WATSON, FREDERICK MORGAN, E. M., ... 1885.
Consolidated Gold Fields of South Africa, Buluwayo, Rhodesia, South Africa, and 403 Sibley Street, Cleveland, Ohio.

1885, Assayer and Surveyor, La Maria Mining Co., Mexico. 1886–89, Engineer, Mill Superintendent, Sombrerete Mining Co., Mexico. Concentration and Lixiviation. 1890, Engineer for Peru Exploration Syndicate, Ltd., Peru. 1891 to date, Examining Engineer for Frecheville Bros. Special Experience in Roasting Rebellious Ores. Lixivation by Russell Process and Superintendent as above. Superintendent "Cia Andes" till 1895. 1896, Engineer Consolidated Gold Fields of South Africa.

WATSON, ROLLA BARNUM, E. M., ... 1891.
Care Daly Mining Co., Park City, Utah, and 403 Sibley Street, Cleveland, Ohio.

Assayer, Candemena, Mexico, 1891. Supt. Erection of Power Plant for Electric Street R. R., Atlanta, Ga., 1892. September, 1893, with Dewey-Walter Refining Co., Marsac Mill, Park City, Utah. December, 1893, to date, Superintendent Dewey-Walter Refining Co. Also from May, 1895, Foreman Marsac Leacher.

WEDEKINT, EDWIN HUTTER, PH. B., ... 1889.
Address unknown.

WEED, WALTER HARVEY, E. M., ... 1883.
U. S. Geological Survey, Washington, D. C., and care S. R. Weed, South Norwalk, Conn.

1883 to date, Geologist on the United States Geological Survey. 1883–89, general geology of the Yellowstone National Park, especially of sedimentary rocks, with examinations of the adjacent mining regions. 1890, structural and economic geology of the country north of the Yellowstone Park, with special studies of the coal-fields of Montana. Specialty, economic and stratigraphic geology. Publications: "A Deadly Gas-spring in the Yellowstone National Park."—*Science.* "The Diatom-beds and Marshes of the Yellowstone National Park."—*Bot. Gazette.* "The Formation of Hot Spring Deposits."—Ninth Annual Report of the Director U. S. Geological Survey. "Geysers."—SCHOOL OF MINES QUARTERLY. "Notes on the Coal-Fields of Montana."—SCHOOL OF MINES QUARTERLY. "The Cinnaba and Bozeman Coal-Fields of Montana."—*Bulletin Geological Society of America,* and other papers.

WEEKS, WILLIAM HOLDEN, PH. B., ... 1889.
789 Madison Avenue, New York City.

1889–90, Assistant Chemist New York Chemical Manufacturing Company, April, 1890, to date, Assistant Chemist Health Department, New York City.

WELCH, ALEXANDER MCMILLAN, PH. B. (Arch), . 1890.
447 Lexington Avenue, New York City.

1890–91, in architect's office. 1891–93, McKim Fellow, travelling in Europe. 1893 to date, as above.

WELLS, JAMES SIMPSON CHESTER, PH. B., PH. D., . 1875.
Columbia College, School of Mines, New York City, and 222 Union Street, Hackensack, N. J.

1875–79, Assistant in Quantitative Analysis, School of Mines. Vacation of 1877, spent as Night Superintendent Pennsylvania Lead Works. 1879–93, Instructor in Qualitative Analytical Chemistry, School of Mines.

WERTHEIMER, LEWIS, PH. B., ... 1887.
Western and Bedwell Streets, Allegheny City, Pa.

WESTERVELT, WILLIAM Y., E. M., ... 1894.
Ducktown Sulphur, Copper and Iron Co., Isabella, Polk County, Tenn., and 1168 Broadway, New York City.

1894–95, Chemist and Surveyor, Ducktown Sulphur, Copper and Iron Co., Ltd. 1895 to date, Engineer and Chemist, same company.

WHEELER, HERBERT ALLEN, E. M., ... 1880.
Security Building, and 3124 Locust Street, St. Louis, Mo.

During 1880, Assistant Geologist in Utah, on U. S. Geological Survey. During 1881, Assistant Engineer Denver and Rio Grande Western Railroad, in Utah and Colorado, on location and construction. During 1882, Superintendent Vermont Copper Company, Ely, Vermont. From 1883 to 1894, at Washington University, St. Louis; Adjunct Professor of Mining; also Consulting Mining Engineer. Since 1891, Assistant Missouri Geological Survey. 1894, Consulting Mining Engineer. Also Secretary Standard Tile Co.

WHITE, ROBERT DAVIS, C. E., ... 1892.
East River Gas Co., 138 W. Forty-second Street, and 39 E. Seventy-fourth Street, New York City.

WHITE, THEODORE G., PH. B., M. A., ... 1894.
Geol. Department, Columbia College, and 39 West Twenty-sixth Street, New York City.

Summer of 1893, Working on the Geology of the Lake Champlain region. Summer of 1894, traveling and examining mining regions surrounding the Great Lakes in Canada and United States, also researches on the Geology of Mt. Desert Island, Maine. 1894 and 1895, Post-Graduate Student in Geology. Researches on the Trenton formation of the Lake Champlain Valley. 1895, Lecturer, N. Y. Board of Education.

WHITING, LOWE, E. M., ... 1895.
Care Messrs. Gaminara & Selder, Tumaeo, Rep. Colombia, S. A.

WHITELOCK, HERBERT PERCY, C. E., ... 1889.
Assistant in Mineralogy, Columbia College School of Mines, and 449 Park Avenue, New York City.

WIECHMANN, FERDINAND G., PH. B., PH. D., . . 1881.
Instructor in Chemical Philosophy and Chemical Physics, Columbia College School of Mines, and 671 West End Avenue, New York City.

Consulting Chemist American Sugar Refining Co., Brooklyn, N. Y.

WIENER, WILLIAM, A. M. PH. B., ... 1891.
Newark High School, and 62½ Nelson Place, Newark, N. J.

1891-92, Chemist to the Hanson, Van Winkle Co., Newark, N. J. 1892-93, Chemicals for Electro-plating, 87 and 89 Mechanic Street, Newark, N. J. 1893, to date, Instructor in Newark High School, and general chemical practice.

WILLIAMS, GRANVILLE WHITTLESEY, E. M., C. E., . 1879.
333 Genesee Street, Utica, N. Y.

WILLIAMS, JOHN TOWNSEND, E. M., PH. B., . . . 1873.
Architect and Builder, 906–914 New York Life Bldg., 346–348 Broadway, and 871 Madison Avenue, New York City.

WILLIAMS, WILLIAM FISH, C. E., E. M., . . . 1881.
City Engineer, 224 Pleasant Street, New Bedford, Mass.

1890, while filling the position of Assistant Engineer to A. B. Drake, Civil

Engineer, of New Bedford, I accepted the position of Chief Engineer to the Cumberland Lands, Ltd., of Stewart County, Tenn. P. O. address, Dover. 1892, Assistant Manager and Engineer to the same Company; later, Chief of the Dept. of Mining, Construction and Engineering, and also Assistant Manager in the same Company. 1893, resigned, and came to New Bedford. Elected City Land-Surveyor and City Engineer with the old title of City Surveyor to the City of New Bedford.

WILLIS, BAILEY, E. M., C. E., ... 1878.

U. S. Geological Survey, Washington, D. C.

June, 1879, to July, 1881, Special Agent Tenth Census; sampler of iron ores and student of iron deposits in states east of the Mississippi river. August, 1881, to June, 1884, Geologist in charge of Pacific division of Northern Transcontinental Survey, chiefly engaged in coal explorations in Washington, Oregon and Montana. July, 1884, to February, 1889, Assistant Geologist U. S. Geological Survey, working in Tennessee and North Carolina. March, 1889, to June, 1893, Geologist in charge of Appalachian division, U. S. Geological Survey, directing work and studying geologic problems of the Palæozoic rocks south of Pennsylvania. 1891-93, Editor of Geologic Maps for Folios of the Geologic Atlas of the United States.

WILSON, HERBERT M., C. E., ... 1881.

U. S. Geological Survey, Washington, D. C.

1881-82, Leveller and Transitman, afterwards Chief of Preliminary party, S. & D. R. R., Mexico. 1882-88, Topographer U. S. Geological Survey. 1889-90, Division Engineer, U. S. Irrigation Surveys. 1891, Geographer, U. S. Geological Survey. 1894, Chief Geographer.

WILSON, WILLIAM ALEXANDER, E. M., . . . 1882.

University Club, Salt Lake City, Utah.

Assayer for two and a half years. Superintendent of Sampling Mill for two years. Superintendent of 30-Stamp Mill (dry crushing, chloridizing, amalgamating and lixiviating, capacity sixty tons per day) for five years. Specialty, treatment of silver and gold ores and examining and reporting on mining properties. Superintending of Mining or Milling operations.

WILTSIE, ERNEST ABRAM, E. M., ... 1885.

General Manager Geldenhuis Fst. and Gold Mining Co., Johannesburg, South African Republic.

1885-86, Assistant Chemist Edgar Thomson Steel Works, Braddock, Pa. 1886 to May, 1887, Chemist Colorado Coal and Iron Company, Pueblo, Colo. May, 1887, to August, 1888, Chemist for the Globe Smelting and Refining Company, Denver, Colo. August, 1888, to April, 1890, Assistant Superintendent North Star Mining Company, Grass Valley, Cal. April, 1890-91, Superintendent Menlo Mines, Grass Valley, Cal. January, 1892, Expert work, Nevada Co., Cal. January to August, 1892, with California State Mining Bureau. August, 1892, to January, 1893, Expert work through California. April, 1893, Manager Gold Mines for Barnato Bros., Johannesburg, So. Africa. July 1, 1894, Geldenhuis Est. and Gold Mining Co., Johannesburg, S. A. Rep.

WINDOLPH, AUGUSTUS PAUL, PH. B., ... 1892.

Address unknown.

WITTMACK, CHARLES AUGUSTUS, M. S., PH. B., PH. D., . 1882.
79 West 87th Street, New York City.

WOOLSON, IRA HARVEY, E. M., ... 1885.
Columbia College School of Mines, New York City.
1885–86, Assistant Geological Survey of New Jersey. 1886–87, Assistant Assay Department, School of Mines. 1887–89, Assistant, Drawing Department School of Mines. 1891 to date, Instructor Mechanical Engineering and Drawing, School of Mines.

Y.

YEIZAR, ROBERTO, E. M., ... 1895.
A. P. 27, Zacatecas, Mexico, also care C. Viaders, 14–16 South William Street, New York City.

YOUNG, EDWARD LEAVITT, E. M., ... 1882.
80 Broadway and 317 West Eighty-ninth Street, New York City.

HONORARY MEMBERS.

CHANDLER, CHARLES F., PH. D.
Professor of Chemistry, School of Mines, Columbia College. Address, 51 East Fifty-fourth Street, New York City.

EGLESTON, THOMAS, E.M., PH. D.
Professor of Mineralogy and Metallurgy, School of Mines, Columbia College. Address, 35 West Washington Square, New York City.

MILLER, GEORGE M.
Ringwood, New Jersey.

ROOD, O. N., A. M.
Professor of Physics, Columbia College. Address, Columbia College, New York City.

VAN AMRINGE, J. H., A. M., PH. D.
Professor of Mathematics, School of Mines, Columbia College. Address, 66 West Forty-seventh Street, New York City.

WARE, WILLIAM R., B. S.
Professor of Architecture, School of Mines, Columbia College. Address, 126 East Twenty-eighth Street, New York City.

HONORARY MEMBERS DECEASED.

AGNEW, C. R.,	1888.
BARNARD, F. A. P.,	1889.
NEWBERRY, J. S.,	1892.
PECK, W. G.,	1892.
RUTHERFURD, W. P,	1892.
TROWBRIDGE, W. P.,	1892.
FISH, HAMILTON,	1893.

LIST No. 3.

Contains the names of Graduates of the School of Mines, not members of the Alumni Association, nor participating in the benefits of such membership. For this reason great uncertainty prevails as to many of the addresses given, which are the best at hand.

It is very desirable that this list should be shortened as far as practicable by the transfer of names from it to the preceding List, No. 2, under the Rules.

(REVISED TO APRIL, 1896.)

Achen, J. B., Ph. B., ... 1894.
Haworth, N. J.

Adams, W. J., A. M., E. M., ... 1878.
Room 15, No. 132 Market St., San Francisco, Cal.

Adams, W. C., C. E., ... 1884.
47 W. 28th Street, New York City.

Agramonté, José Cesar, C. E., ... 1886.
Address unknown.

Agramonté, I. E., C. E., ... 1893.
Zulieta No. 3, Havana, Cuba.

Alden, Herbert C., E. M., ... 1884.
Address unknown.

Aldrich, C. H., Ph. B., ... 1893.
8 Cushing Street, Providence, R. I.

Anderson, George Mendenhall, Ph. B., ... 1891.
East Walnut Hills, Cincinnati, Ohio.

Andresen, Charles Alfred, E. M., ... 1881.
Pickard & Andresen, 89 Gold Street, New York City.

Appleby, John Storm, Ph. B., A. M., ... 1888.
Architect, 216 West Fifty-ninth Street, New York City.

Aschman, Fred. Theo., Ph. B., ... 1881.
Chemist and Prof. Chemistry, College of Pharmacy, and 86 Water St., Pittsburg, Pa.

Ayestas, Alberto, Ph. B., ... 1883.
Tegucicalpa, Honduras, C. A.

Ayres, W. C., Ph. B., ... 1893.
Address unknown.

Barkley, Howell Finch, E. M., ... 1885.
Address unknown.

Barnard, Aug. Porter, E. M., ... 1868.
125 East Twenty-sixth Street, New York City.

Barros, Louis de Souza, E. M., C. E., ... 1877.
Address unknown.

Beckstein, Charles Alfred, Ph. B., ... 1888.
336 West Forty-sixth Street, New York City.

Beckwith, Charles Ellsworth, Met. Eng., ... 1888.
Address unknown.

Beckwith, George Alexander, C. E., ... 1890.
Paterson, N. J.

Behlen, Herman, Ph. B., ... 1890.
125 East One Hundred and Fifteenth Street, New York City.

Behr, Edward, C. E., ... 1877.
426 Henry Street, Brooklyn, N. Y.

Bell, Henderson M., Jr., E. M., ... 1886.
Bramwell, Mercer Co., W. Va.

Bergen, Chas. Hill, C. E., ... 1892.
Red Bank, N. J.

Berry, Gerald, C. E., ... 1889.
78 Morton Street, Brooklyn, N. Y.

Black, Alex. L., E. M., ... 1890.
56 Carondelet Street, New Orleans, La.

Bleecker, Charles Popham, E. M., ... 1881.
446 Avenue E, Bayonne, N. J.

Bliss, Collins Pechin, Ph. B., ... 1891.
60 Cedar St., Room 9, New York City.

Bolles, Randolph, Ph. B., ... 1892.
Englewood, N. J.

Bolton, Robert, Ph. B., M. D., ... 1879.
Assistant Physician, Essex County Insane Asylum, So. Orange Ave., Newark, N. J.

Bossange, E. R., Ph. B., ... 1893.
75 West Forty-fifth Street, New York City.

Brennan, Andrew Joseph, C. E., ... 1885.
Address unknown.

Bridgham, Samuel Willard, E. M., ... 1867.
49 West Twenty-third Street, New York City.

Brinckerhoff, George Charles, E. M., ... 1878.
Apartado 183, Matanzas, Cuba.

Bronson, Edward Stelle, A. B., A. M., E. M., ... 1867.
49 Garden Place, Brooklyn, N. Y.

Brooks, W. F., Ph. B., ... 1893.
335 West Fifty-fifth Street, New York City.

Brown, Robert Gilman. E. M., ... 1889.
Box 956, Butte, Mont.

Bruckman, Frederick, E. M., ... 1869.
U. S. Mint, and 120 West Third Ave., Denver, Colo.

Buckingham, Frederick Endicott, E. M., ... 1884.
Department Public Works, Brooklyn, N. Y.

Buckland, Will A., Ph. B., ... 1890.
36 East Twenty-second Street, New York City.

Bush, William Falkner, E. M., ... 1885.
Address unknown.

Cairns, Fred. Irvan, Met. Eng., ... 1890.
20 Buckingham Avenue, Bridgeport, Conn.

Campbell, Alonzo Clarence, E. M., ... 1869.
Mining Engineer, 306 Russell Street, Nashville, Tenn. Specialty Milling and Concentration.

Canfield, M. C., E. E., ... 1893.
18 Clinton Street, Cleveland, Ohio.

Carrère, Joseph Maxwell, C. E., ... 1883.
36 Park Place, New York City, and New Brighton, N. Y.

Carson, Joseph, C. E., ... 1890.
31 West Fifty-fifth Street, New York City.

Cary, Geo. B., Ph. B., ... 1885.
184 Delaware Avenue, Buffalo, N. Y.

Chapman, A. W., E. E., A. B., ... 1894.
160 Hicks Street, Brooklyn, N. Y.

Churchill, Alfred Daniel, A. M., M. S., E. M., Ph. D., ... 1880.
Helena, Mont.

Clark, Leroy, Jr., E. E., ... 1894.
350 West Fiftieth Street, New York City.

Clayton, William Robert, Ph. B., ... 1890.
Architect, 31 and 32 Rialto Building, Chicago, Ill.

Cloud, Leo George, A. B., E. M., ... 1879.
216 Monmouth Street, Newport, Ky.

Colton, Frederick Gray, Ph. B., ... 1890.
136 Montague Street, Brooklyn, N. Y.

Colt, S. B., Ph. B. . . . . 1888.
1197 Broad Street, Newark, N. J.

Comstock, Claude Nichols, C. E., ... 1888.
Address unknown.

Constant, Charles Louis, E. M., C. E., ... 1877.
32 Park Street, Jersey City, N. J.

Cornwall, George Rockwell, E. M., C. E., ... 1876.
189 Lefferts Place, Brooklyn, N. Y.

Coursen, George Hampton, E. M., C. E., ... 1868.
Address unknown.

Covell, E. C., A. B., ... 1892.
Address unknown.

Covell, W. S., Ph. B. . . . . 1893.
42 West Sixty-sixth Street, New York City.

Coykendall, Thomas Cornell, C. E., ... 1890.
Rondout, N. Y.

Cozzens, Harmon, E. M., ... 1885.
Address unknown.

Cristy, Edward Buxton, Ph. B., ... 1891.
Albuquerque, New Mexico.

Cromwell, James William, Jr., Ph. B., ... 1889.
Architect, 29 Brevoort Place, Brooklyn, N. Y.

Crowell, Charles B., Ph. B., ... 1885.
Minneapolis, Minn.

Curtis, Charles Gordon, C. E., ... 1881.
President Curtis Electrical Mfg. Co., Whiton St., Jersey City, N. J.

Curtiss, C. C., A. B., A. M., ... 1892.
Address unknown.

Davis, William Monroe, E. M., ... 1890.
Syracuse, N. Y.

Del Calvo, Francis, C. E., ... 1884.
Address unknown.

Detwiller, Charles Henry, Ph. B., ... 1885.
Detwiller & Melendy, 97 Nassau Street, New York City, and 56 Danforth Avenue, Jersey City, N. J.

Doolittle, Charles Horace, E. M., ... 1885.
Address unknown.

Downing, Orrien Pinkerton, Ph. B., ... 1878.
116 Battery Street, San Francisco, Cal.

Dunn, Gano Sillick, B. S., E. E., ... 1891.
Elect. Engineer, Crocker-Wheeler Electric Co., Ampere, East Orange, N. J.

[illegible]m, Edward B., E. M., ... 1892.
Mt. Kisko, N. Y.

Eliot, Walter Greame, E. M., C. E., Ph. B., Ph. D., ... 1878.
"University Magazine," 70 South St., and University Club, N. Y. City.

Ellis, A. Van Horn, C. E., ... 1889.
Bartow-on-Sound, N. Y.

Emery, H. G., Ph. B., ... 1894.
Nyack, N. J.

Escobar, Francisco, E. M., ... 1889.
842 Wilson Avenue, Cleveland, Ohio.

Fales, William, E. S., E. M., LL. B., ... 1871.
Amoy, China.

Fellows, William K., Ph. B., ... 1894.
7818 Eggleston Avenue, Chicago, Ill.

Fenner, Clarence Norman, E. M., ... 1892.
Paterson, N. J.

Ferguson, George Albert, Ph. B., ... 1890.
138 Wilson Street, Brooklyn, N. Y.

Fisher, Lloyd Wiegand, Ph. B., ... 1890.
109 E. Twenty-eighth Street, New York City.

Fitch, Charles Lincoln, E. M., ... 1882.
157 Van Buren Street, Brooklyn, N. Y.

Fitch, Josiah Huntingdon, E. M., ... 1884.
Address unknown.

Fitzgerald, George E., E. M., ... 1884.
El Paso, Texas.

Francke, Robert Otto, C. E., ... 1880.
W. Passburg, Esq., Moscow, Russia.

Frankfield, Emil, C. E., ... 1886.
328 W. Fifty-sixth Street, New York City.

Frisbee, H. D., E. E., ... 1894.
Fulton Street, New York City.

Fuentes, Paul, E. M., ... 1894.
321 Hudson Street, Hoboken, N. J.

Gage, Samuel Edson, Ph. B., ... 1887.
Architect, 114 Fifth Avenue, New York City.

Gardner, Watts Denning, C. E., ... 1888.
Board of Health, New York City.

Garrison, Edmund Hoyt, E. M., C. E., ... 1876.
84 Highland Street, Yonkers, N. Y.

Geer, George Jarvis, Jr., E. M., ... 1868.
Merchant, 453 Broome Street, New York City.

Giddings, Edward Everett, E. M., ... 1867.
Merchant, 413 Royal Insurance building, Chicago, Ill.

Gildersleeve, A. C., C. E., ... 1890.
Address unknown.

Goldsmith, Byron Benjamin, Ph. B., ... 1887.
19 East Seventy-fourth Street, New York City.

Gould, Edward Ludlow, C. E., ... 1890.
59 Hawthorne Avenue, Yonkers, N. Y.

Greene, Wilkins Updike, Ph. B., ... 1880.
104 Columbia Heights, Brooklyn, N. Y.

Gregory, L. E., C. E., ... 1893.
406 Passaic Avenue, Kearney, N. J.

Griffin, S. P., Jr., ... 1884.
449 Park Avenue, New York City.

Griffith, Vincent Colyer, Ph. B., ... 1889.
160 Herkimer Street, Brooklyn, N. Y.

Griggs, Wilfred Elizur, Ph. B., ... 1889.
Architect, Waterbury, Conn.

Haas, Harry Leopold, Ph. B., ... 1878.
Carrère and Haas, 36 Park Place, New York City.

Hamilton, Schuyler, Jr., A. B., A. M., E. M., ... 1876.
Croton-on-Hudson, Westchester Co., N. Y., Architect and Brick Manufacturer.

Hanson, R. C., C. E., ... 1894.
79 Manhattan Avenue, New York City.

Harker, Charles Sumner, E. M., ... 1879.
26 Montgomery Street, San Francisco, Cal.

Harmer, Thomas Hayes, A. B., A. M., E. M., ... 1867.
113 East Twenty-seventh Street, New York City.

Harrison, Newton, E. E., ... 1892.
Elect. Engr., 136 Liberty Street, New York City.

Hart, Burnham, C. E., ... 1885.
Ramsay, N. J.

Hart, Charles Henry, C. E., ... 1890.
199 Lenox Avenue, New York City.

Hasegawa, Yothinosuke, E. M., Ph. D., ... 1878.
Mitsu Bishi Sha, No. 11, Awajicho, Nichome Kanda, Tokio, Japan.

Hawkes, Emil MacDougal, A. B., E. M., ... 1885.
267 Fifth Avenue, New York City.

Hay, Arthur, E. M., ... 1892.
821 South Second Street, Springfield, Ill.

Heinze, Frederick Augustus, E. M., ... 1889.
General Manager Montana Ore Producing Co., Butte, Montana.

Hemmer, Frederick Adolph, Ph. B., ... 1881.
Box 6, Edgewater, N. J.

Hooper, Louis Mosher, C. E., ... 1880.
Rutherford, N. J.

Holter, Norman Bernard, E. M., ... 1891.
A. M. Holter Hardware Co., Helena, Mont.

Horn, James Thurston, A. B., C. E., ... 1884.
Naval Architect, and 13 E. Fifty-third Street, New York City.

Hornbostel, Henry Frederick, Ph. B., ... 1891.
39 Second Place, Brooklyn N. Y.

Hoyt, John Sherman, C. E., ... 1890.
934 Fifth Avenue, New York City.

Hoyt, R., C. E., ... 1893.
Katonah, N. Y.

Hudson, Edward Henry, C. E., ... 1880.
Address unknown.

Huntting, Henry Ogden, Ph. B., ... 1887.
Architect, 454 Ceasson Avenue, Brooklyn, N. Y.

Ives, Arthur Stanley, C. E., E. E., ... 1889.
33 Sidney Place, Brooklyn, N. Y.
Jackson, Charles Edward, C. E., ... 1875.
15 Courtland Street, New York City.
Jacobs, H. H., Ph. B., ... 1894.
107 E. Seventy-eighth Street, New York City.
Jarmulowsky, Meyer, Ph. B., ... 1890.
27 Jefferson Street, New York City.
Joffe, Mayer, C. E., ... 1894.
Verona, N. J.
Jenney, Walter Proctor, E. M., Ph. D., ... 1869.
Rapid City, South Dakota.
Jones, E. M., C. E., ... 1894.
312 W. Twenty-eighth Street, New York City.
Jones, Thomas John, Met. Eng., ... 1890.
Pulaski City, Va.
Jordao, Jose Nabor Pacheco, C. E., E. M., Ph. B., ... 1877.
Address unknown.
Judd, Charles Breck, E. M., ... 1881.
Westinghouse Building, Pittsburg, Pa.
Karr, C. P., Ph. B., ... 1878.
1 Union Square, West, New York City.
Keeler, Frederick Sterling, Ph. B., ... 1891.
530 Bouch Avenue, Buffalo, N. Y.
King, Charles, Ph. B., ... 1876.
Railroad contractor, King & Dickinson, Tacoma, Wash.
Kletchka, John Joseph, A. B., C. E., ... 1892.
247 Willis Avenue, New York City.
Knapp, John Augustus, A. B., A. M., E. M., ... 1870.
Chicago and Aurora Smelting Co., Chicago, Ill.
Knox, Charles E., E. E., ... 1892.
Jas. W. Queen & Co., Philadelphia, Pa.
Kohn, Robert David, Ph. B., ... 1890.
4 Rue Honoré Chevalier, Paris, France.
Korn, Louis, Ph. B., ... 1890.
261 Broadway, New York City.
Ledoux, Augustus Damon, Ph. B., ... 1881.
P. O. Box 426, Richmond, Va.
Lee, Henry Charles, C. E., ... 1886.
127 East Twenty-first Street, New York City.
Lichtenstein, Edward Gervaise, Ph. B., ... 1890.
14 W. Seventy-fourth Street, New York City.
Lindsley, Stewart, E. M., ... 1870.
Orange, N. J.
Livingston, Goodhue, Ph. B., ... 1892.
Geo. B. Post, Century Bldg., New York City.
Lord, Nathaniel Wright, E. M., ... 1876.
Professor Mining and Metallurgy, Ohio State University, Columbus, O.
Lowndes, William Shepherd, Ph. B., ... 1890.
42 Sherman Place, Jersey City, N. J.

McDowell, Frederick H., E. M., ... 1872.
66 Cortlandt Street, New York City.
McIlvaine, Alexis Reed, Ph. B., ... 1888.
Architect, 48 Exchange Place, New York City.
McKee, H. S., E. M., ... 1893.
Los Angeles Terminal Railway Co,, Los Angeles, Cal.
McKinlay, James Buell, E. M., ... 1892.
108 W. Seventy-ninth Street, New York City.
McKleroy, William Henry, Met. Eng., ... 1890.
Cashier Anniston National Bank, Anniston, Ala.
McNeil, Charles R., Ph. B., ... 1894.
Litchfield, Conn.
Macy, V. E., Ph. B., ... 1893.
18 West Fifty-third Street, New York City.
Maghee, John Holme, A. B., A. M., C. E., ... 1876.
Cayuga Lake Ice Line, Rochester, N. Y., and 29 East Thirty-second Street, New York City.
Mahl, J. Thomas, C. E., ... 1891.
G. H. & S. A. R. R. Co., Houston, Texas.
Mann, C. R., A. B., A. M., ... 1891.
Address unknown.
Mann, Horace Borchsenius, Ph. B., ... 1890.
Orange, N. J.
Mapes, Charles Halstead, Ph. B., ... 1889.
60 West Fortieth Street, New York City.
Marsh, Charles Wells, Ph. B., Ph. D., ... 1879.
435 Fifth Avenue, New York City.
Matthews, Charles Thompson, Ph. B., ... 1889.
Architect, Elm Park, Norwalk, Conn.
Matthew, W. D., Ph. B., ... 1893.
St. John, N. B., Canada.
Matsui, Nawokichi, Ph. B., Ph. D., ... 1878.
Agricultural College, Konaba, Tokio, Japan.
Mattison, Joseph Godley, Ph. B., ... 1880.
Real Estate and Insurance Broker, 20 W. Fourteenth Street, New York City.
Meikleham, Thomas Mann Randolph, C. E., ... 1890.
Jamaica, Long Island, N. Y.
Merwin, H. J., E. M., ... 1879.
Middlesborough, Ky.
Mesa, Antonio Esteban; C. E., ... 1882.
Address unknown.
Mears, George K., E. E., ... 1894.
Elizabeth, N. J.
Moeller, Rudolph, Ph. B., ... 1887.
336 West Twenty-ninth Street, New York City.
Morgan, J. L., Ph. B., ... 1888.
47 Fulton Street, New York City.
Morewood, George Barrow, E. M., Ph. D., ... 1878.
156 West Seventy-sixth Street, New York City.
Morewood, Henry Francis, E. M., Ph. D., ... 1876.
Importer, Box 2087, New York City.

Morris, B. W., Jr., Ph. B., ... 1894.
33 West Forty-second Street, New York City.
Mott, Henry Augustus, Jr., Ph. B., E. M., Ph. D., ... 1873.
Mining Engineer and Analytical Chemist, 155 Broadway, New York City.
Munroe, M., E. E., ... 1894.
Address unknown.
Murray, George, E. M., ... 1874.
235 West Twenty-third Street, New York City.
Murchison, K. M., Jr., Ph. B., ... 1894.
46 West Fifty-seventh Street, New York City.
Nambu, Kingo, E. M., ... 1878.
Nagasaki, Japan.
Nettre, L. R., E. M., ... 1869.
26 Coventry Street, W., London, England.
Newton, T. M., Ph. B., ... 1893.
40 West Seventy-fifth Street, New York City.
Neymann, Percy, Ph. B., Ph. D., ... 1881.
Chemist and Assistant Superintendent, 36 Michigan Street, Cleveland, O.
Nicholas, Harry Parmelee, E. M., ... 1887.
Hotel St. George, 49 East Twelfth Street, New York City.
Noble, Charles Milton, E. M., ... 1879.
Manager Ruttan Mfg. Co., Anniston, Ala.
Oakes, J. C., B. S., Ph. B., ... 1893.
423 West Twenty-first Street, New York City.
Oseranski, Isaac Henry, C. E., ... 1889.
Address unknown.
Owens, Robert Bowie, E. E., ... 1892.
Professor Elect. Engineering, Univ. of Nebraska, Lincoln, Neb.
Oxnard, James Guerrero, Ph. B., ... 1883.
Norfolk, Neb.
Palmer, Cortlandt, Edward, E. M., ... 1878.
Colorado Springs, Colo.
Parmly, Chas. Howard, B. S., E. E., ... 1892.
344 W. Twenty-ninth Street, New York City.
Parsons, H. A., C. E., ... 1894.
South Norwalk, Conn.
Parsons, George H., E. M., ... 1868.
Colorado Springs, Col.
Pazos, Vincent Felix, E. M., ... 1878.
Address unknown.
Pearce, R., Ph. D., ... 1890.
Address unknown.
Pederson, F. M., B. S., E. E.,. . . . . 1893.
327 W. Thirty-fourth Street, New York City.
Pelton, H. C., Ph. B., ... , 1890.
Address unknown.
Perry, Nelson W., E. M., ... 1878.
Editorial Staff "Electrical World," New York City.
Pfister, Philip Charles, E. M., ... 1875.
Address unknown.

Pierce, Harry Nelson, E. M., ... 1885.
Address unknown.

Platt, Charles Slason, E. M., ... 1868.
Assayer, 21 and 31 Gold Street, New York City.

Pomeroy, W. A., E. M., ... 1893.
Oswego, Oregon.

Pope, J. R., Ph. B., ... 1894.
111 E. Twenty-fifth Street, New York City.

Portuondo, Jose, C. E., ... 1890.
San Basilio, Alta 28, Santiago, Cuba.

Post, R. B., Ph. B., ... 1893.
Elizabeth, N. J.

Post, William Stone, Ph. B., ... 1890.
Bernardsville, N. J.

Powers, Cornelius Van Vorst, Ph. B., ... 1882.
Assistant Engineer Aqueduct, Katonah, N. Y.

Primelles, Jose Alejandro, C. E., ... 1887.
Mercedes 23, Puerto Principe, Cuba.

Prince, A. D., C. E., ... 1893.
30 W. Forty-seventh Street, New York City.

Prince, John L., E. E., ... 1894.
868 Flatbush Avenue, Brooklyn, N. Y.

Proctor, William Ross, E. M., ... 1884.
43 and 45 Sixth Avenue, Pittsburg, Pa.

Provot, F. A., C. E., ... 1893.
Box 166, Orange Valley, N. J.

Provot, George, Ph. B., ... 1889.
Architect, 24 Highland Terrace, Orange, N. J.

Radford, William Helsham, E. M., ... 1877.
Lydenburgh Gold Mining Co., Limited, Manchester, Eng.

Randolph, Edmund, Ph. B., ... 1883.
E. & C. Randolph, 7 Nassau St., New York City ; also Knickerbocker Club.

Raymer, George Sharp, A. B., E. M., ... 1881.
Mine Superintendent, Idaho Springs, Colorado, and 63 Seventh Avenue, Brooklyn, N. Y.

Raymond, Alfred, Ph. B., ... 1891.
123 Henry Street, Brooklyn, N. Y.

Reed, William Bell Stephen, E. M., ... 1879.
Helena, Mont.

Rees, B. F., E. M., ... 1874.
Chattanooga, Tenn.

Reese, William W., A. B., E. E., ... 1892.
New Hamburg, N. Y.

Rennard, John C., E. E., ... 1894.
302 W. Seventy-third Street, New York City.

Reynolds, M. T., A. B., Ph. B., ... 1893.
98 Columbia Street, Albany, N. Y.

Richmond, William Thomas, Ph. B., ... 1881.
68 Thomas Street, New York City.

Riggs, Geo. Washington, Ph. B., ... 1871.
Summit, N. J.

Rittenhouse, Charles T., E. E., ... 1894.
247 W. 138 Street, New York City.
Roberts, Arthur Carr, E. M., ... 1881.
Address unknown.
Roberts, Gracie Sayre, E. M., C. E., ... 1871.
Sewer Bureau, Dept. City Works, Brooklyn, N. Y.
Robertson, Kenneth, E. M., ... 1868.
General Manager West Superior Iron and Steel Co., W. Superior, Wis.
Robertson, Richard Spotswood, Jr., E. M., ... 1871.
Jackson, Minn.
Robinson, F. G., E. E., ... 1893.
Superintendent Amsterdam Street Railway, Amsterdam, N. Y.
Robinson, Henry Alvord, Ph. B., ... 1880.
Lawyer, 150 Broadway, New York City.
Rogers, Charles Louis, E. M., C. E., ... 1877.
823 Broad Street, Chattanooga, Tenn.
Ross, William Coleman, C. E., E. M., ... 1876.
Address unknown.
Rutherford, Lewis Hopkins, E. M., ... 1887.
Franklin, Pa.
Sanders, Wilbur Edgerton, E. M., ... 1885.
Mine Supt., Ewing and Seventh Avenue, Helena, Mont.
Savage, Seward Merrill, C. E., ... 1892.
2260 Pacific Street, Brooklyn, N. Y.
Sawyer, Charles Pike, Ph. B., ... 1881.
Address unknown.
Searle, Charles D., C. E., ... 1894.
32 W. 126th Street, New York City.
Shack, Albert P., E. M., ... 1868.
Address unknown.
Sherman, C. F. G., C. E., ... 1894
1138 Seventh Street, Boisé City, Idaho.
Shope, Henry Brengle, Ph. B., ... 1885.
19 West Thirty-second Street, New York City.
Skidmore, Samuel Tredwell, A. B., Ph. B., ... 1889.
71 West Fiftieth Street, New York City.
Sloane, Thomas O'Connor, A. B., A. M., E. M., Ph. D., ... 1872.
South Orange, N. J.
Small, Franklin Maurice, Ph. B., ... 1889.
Architect, 199 Second Avenue, New York City,
Smeaton, William Henry, C. E., E. M., ... 1877.
15 Horatio Street, New York City.
Smedberg, Henry Ashton, A. B., C. E., ... 1884.
347 Fifth Avenue, New York City.
Smith, H. A., Ph. B., ... 1893.
460 West Forty-fourth Street, New York City.
Smith, Maxwell, C. E., ... 1890.
Adon Smith, 8 Bridge Street, New York City.
Smyth, Roland Mulville, E. M., C. E., ... 1877.
452 Produce Exchange, New York City. 1879 to date, banker and broker.

Speyers, Clarence Livingston, Ph. B., ... 1884.
Associate Professor Chemistry, Rutgers College, New Brunswick, N. J.
Stallnecht, Frederick, E. M., ... 1868.
Editor, 11 Bond Street, New York City.
Starr, Henry Fowler, Ph. B., ... 1879.
91 Mt. Pleasant Avenue, Newark, N. J.
Steers, James Rich, Ph. B., ... 1890.
10 East Thirty-eighth Street, New York City.
Steinam, J. L., Ph. B., ... 1894.
31 W. Ninety-fifth Street, New York City.
Stevens, Alexander, C. E., ... 1887.
No. 1 Newark St., Hoboken, N. J.
Stewart, Hunter, E. M., ... 1875.
Address unknown.
St. John, Thomas Matthew, Met. Eng., ... 1890.
New York City.
Stoughton, Arthur Alexander, Ph. B., ... 1888.
1665 Washington Avenue, New York City.
Stoughton, Charles William, C. E., ... 1889.
1665 Washington Avenue, New York City.
Stratton, Alex., E. E., ... 1894.
2013 Fifth Avenue, New York City.
Strieby, William, A. M., E. M., ... 1878.
Professor of Metallurgy and Assaying, Colorado College, Colorado Springs, Colo.
Strout, William Allen, Ph. B., ... 1891.
366 Carlton Avenue, Brooklyn, N. Y.
Suydam, John Richard, Jr., E. M., ... 1879.
14 East Forty-first Street, New York City.
Tennille, George F., Ph. B., ... 1894.
Central Lard Co., 519 West Thirty-third Street, New York City.
Thomas, Franz Charles, Ph. B., ... 1891.
39½ Washington Square, New York City.
Thompson, Milton Strong, Ph. B., ... 1875.
Chemist, Newburyport, Mass.
Thompson, S. C., A. B., E. M., ... 1893.
Grass Valley, Nevada Co., Cal.
Thorne, William Lincoln, Ph. B., ... 1890.
63 High Street, Yonkers, N. Y.
Tilghman, H. A., E. M., ... 1893.
Sanslito, Cal.
Tompkins, J. A., Ph. B., ... 1894.
223 E. Seventeenth Street, New York City.
Totten, George Oakley, Jr., Ph. B., (1892) . . . . . 1891.
62 North Eleventh Street, Newark, N. J.
Toucey, Donald Butler, LL. B., E. M., ... 1882.
743 Madison Avenue, New York City.
Towart, James, C. E., ... 1892.
Box 296, Peekskill, N. Y.
Trowbridge, Samuel Breck Parkman, A. B., Ph. B., ... 1886.
Architect, 7 East Forty-sixth Street, New York City.

Tucker, Allen, Ph. B., ... 1888.
80 Washington Square E., New York City.
Tucker, John Henry, Ph. B., Ph. D., ... 1875.
Globe Smelting and Refining Co., Denver, Colo.
Tuttle, W., Ph. B., ... 1893.
520 Summer Avenue, Newark, N. J.
Tuttle, William W., E. M., ... 1867.
Springfield, Mo.
Van Boskerck, Robert Ward, E. M., ... 1877.
Artist, 58 West Fifty-seventh Street, New York City.
Van Brunt, Arthur Hoffman, Ph. B., ... 1886.
Architect, 54 Wall Street, New York City.
Vanderbilt, W. D., C. E., ... 1894.
44 Monroe Place, Brooklyn, N. Y.
Van Ingen, Dudley Arthur, Ph. B., ... 1892.
135 Henry Street, Brooklyn, N. Y.
Van Lennep, David, E. M., ... 1868.
Auburn, Placer County, Cal. Fruit ranch.
Vatable, J. J., Ph. B., ... 1894.
89 Water Street, New York City.
Wainwright, Richard Tighe, C. E., ... 1890.
Rye, N. Y.
Wallace, William J., Ph. B., ... 1886.
Whitestone, N. Y.
Wallbridge, Frederich Kidder, E. M., ... 1884.
37 Ninth Avenue, Brooklyn, N. Y.
Walker, Joseph, Jr., C. E., ... 1880.
112 East Thirty-seventh Street, New York City.
Wanier, Albert George, Ph. D., ... 1882.
Kreisherville, Staten Island, N. Y.
Ward, Norbert Reillieux, E. M., ... 1882.
Morgan Furn Co., 1180 Broadway, New York City.
Ware, F. B., Ph. B., ... 1894.
1285 Madison Avenue, New York City.
Warren, Charles Peck, Ph. B., A. M. (1892), ... 1890.
286 Clifton Place, Brooklyn, N. Y.
Warren, Lloyd, Ph. B., ... 1891.
520 Fifth Avenue, New York City.
Waterbury, Cornelius Reed, C. L., C. E., LL. B., ... 1877.
Lawyer, 45 Broadway, New York City.
Waters, George Safford, Ph. B., ... 1889.
Architect, Andrews, Waters & Sherwin, 42 W. Forty-third St., N. Y. City.
Webb, Henry Walter, E. M., LL. B. . . . . 1873.
Third Vice-President, N. Y. C. & H. R. R. R., and 15 West Forty-seventh Street, New York City.
Wels, Paul O., E. M., B. S., ... 1887.
127 East Ninety-first Street, New York City.
Welsh, Howard Farrington, E. M., ... 1890.
Mingo Mountain Coal and Coke Co., Hartranft, Tenn.
Werner, Henry Clay, Ph. B., ... 1892.
120 East Sixty-fifth St., New York City.

Wetmore, Edwin Atwater, E. M., ... 1875.
Iron Merchant, Marquette, Mich.

Wheatley, Joseph Yendes, C. E., ... 1886.
30 S. Ninth Street, Newark, N. J.

White, Wm. Sherf, E. M., ... 1882.
430 Gold St., Brooklyn, N. Y.

Whitman, Edmund Pineo, E. M., ... 1885.
50 Beacon Street, Boston, Mass.

Williams, Frederick Harrison, E. M., ... 1874.
Riverside Iron Works, and 34 Virginia Street, Wheeling, W. Va.

Wilson, Clarence Edgar, Ph. B., ... 1886.
Address unknown.

Windecker, Clifton Nicholas, C. E., ... 1892.
33 Sidney Place, Brooklyn, N. Y.

Wood, George E., E. M., Ph. B., ... 1884.
Architect, 63 William Street, New York City.

Wright, Albert Allen, A. M., Ph. B., ... 1875.
Professor of Geology and Natural History, Oberlin College, Oberlin, Ohio.

LIST No. 4.

Contains the names of Members of the Alumni Association classified territorially by residence. Those not members of the Association are not included by reason of the uncertainty as to address of such persons.

(Revised to April, 1896.)

Alabama.—*Henry Ellen*, J. J. Ormsbee; *Tuscaloosa*, S. Friedman.

Arizona.—*Congress*, W. F. Staunton; *Harqua Hala*, R. M. Raymond.

California.—*Los Angeles*, W. F. Brugman, L. C. Easton; *Napa City*, E. Goodwin; *Palo Alto*, L. R. Lenox; *San Francisco*, D. E. Mellis; E. C. Van Blarcom; *Selby*, E. N. Engelhardt; *Stockton*, E. F. Haas.

Colorado.—*Aspen*, A. F. Bardwell, C. W. Miller; *Boulder*, B. C. Hinman; *Colorado Springs*, Geo. Müller, W. E. Newberry; *Crested Butte*, Frederick Bayles; *Cripple Creek*, F. C. Hamilton; *Denver*, H. V. F. Furman, W. L. Hoyt, M. W. Iles, C. F. Lacombe, B. B. Lawrence, G. A. Schroter, T. B. Stearns; *Durango*, E. J. H. Amy; *Glenwood Springs*, W. B. Devereux; *Leadville*, L. S. Noble; *Pueblo*, A. S. Dwight, E. C. Eddy, H. E. Eilers, M. B. Holt; *State College*, M. C. Ihlseng; *Telluride*, T. F. Van Wagenen.

Connecticut.—*Collinsville*, W. Hill; *Milford*, C. R. Harte.

Delaware.—*Wilmington*, H. G Haskell.

District of Columbia.—*Washington*, E. C. Barnard, J. S. Cox, Jr., E. M. Douglass, A. W. Dow, W. T. Griswold, H. Hollerith, F. W. Tower, W. H. Weed, B. Willis, H. M. Wilson.

Georgia.—*Rockinart*, F. Powell; *Savannah*, D. B. Falk.

Illinois.—*Carthage* J. C. Ferris; *Chicago*, E. G. Barratt, S. S. Fowler, H. L. Hollis, C. L. Miller, R. Mulford, S. B. Peck, F. B. F. Rhodes, W. H. Van Arsdale, L. Wampold; *West Aurora*, A. G. Johnson.

Idaho.—*Moscow*, E. Goodwin; *Rocky Bar*, E. C. Koch.

Indiana.—*Indianapolis*, B. J. T. Jeup; *Muncie*, J. R. Marsh.

Indian Territory.—*Hartshorn*, E. Ludlow.

Iowa.—*Davenport*, F. P. Bemis, E. Gudeman, E. W. Guiterman; *Ottumwa*, S. S. Rice.

Kansas.—*Argentine*, H. Garlichs.

Louisiana.—*New Orleans*, A. L. Black, G. S. Eastwick, E. P. Eastwick.

Maryland.—*Baltimore*, A. L. Walker; *Glencoe*, E. A. McCulloh.

Massachusetts.—*Boston*, Francis Blossom, A. J. Malukoff; *Cambridge*, J. A. Noyes; *New Bedford*, N. Hathaway, W. F. Williams; *Springfield*, L. J. Powers.

Michigan.—*Houghton*, R. M. Edwards, F. McM. Stanton; *Marquette*, R. A. Parker; *Trenton*, E. D. Church; *Vulcan*, W. Kelly.

Minnesota.—*Minneapolis*, W. R. Appleby, F. W. Denton; *Soudan*, C. B. Crowell.

Missouri.—*Carthage*, A. O. Ihlseng; *De Soto*, O. M. Munroe; *St. Louis*, E. H. Harris, W. B. Potter, E. Starek, A. Thacher, H. A. Wheeler.

Montana.—*Bozeman*, A. M. Ryon, F. W. Traphagen; *Butte*, F. Kleptko, F. Sands, S. D. Gifford; *Helena*, W. H. Aldridge, H. M. Cole, P. A. L. Mannheim, J. R. Parks, C. F. Pearis; *Smelter*, A. F. Emrich, F. M. Smith.

Nevada.—*Delamar*, R. Nichols.

New Jersey.—*Bayonne*, C. P. Bleecker; *Bloomfield*, N. Butler, Jr.; *Dover*, F. A. Canfield; *Englewood*, W. W. Burritt; *Fort Lee*, C. G. Massa; *High Bridge*, C. Le Boutillier; *Jersey City*, J. R. Binion, W. F. Downs, P. C. McIlhiney, R. H. Vondy; *Mamaroneck*, F. P. Smith; *Maurer*, G. B. Lee; *Morristown*, J. R. Brinley, J. P. Pennington; *Newark*, H. G. Atha, C. A. Colton, C. E. Graff, A. W. Jenk, F. W. Kinsey, E. Merz, H. M. Murphy, G. C. Stone, E. G. Tuttle, F. Vanderpoel, E. Waller, W. Wiener; *New Brunswick*, A. H. Chester, W. D. Horne; *Orange*, R. K. Mosley; *Paterson*, L. D. Huntoon; *Perth Amboy*, D. F. Haasis, A. F. Schneider; *Plainfield*, F. A. Cokefair, C. Bullman; *Princeton*, H. B. Cornwall; *South Orange*, E. D. Self; *Trenton*, J. H. Janeway, F. E. Pierce.

New York.—*Albany*, H. P. Gillette, F. J. H. Merrill; *Brooklyn*, R. L. Allen, P. T. Austen, F. R. Bartlett, G. W. Behrman, G. Berry, J. R. Bien, F. Blossom, D. D. Book, G. H. Casamajor, J. S. Cox, E. P. Clark, J. T. Corcoran, J. A. Deghnée, F. D. Dodge, H. W. Durham, W. L. Dusenberry, L. G. Engel, E. P. Folger, A. D. Granger, S. A. Goldschmidt, W. A. Herckenrath, J. M. Hewlett, E. D. Hurlburt, F. S. Hyde, W. D. Jones, F. Lyman, W. M. Meserole, J. Middleton, J. Nesmith, T. S. Perkins, A. J. Provost, C. B. Rowland, G. Rowland, R. Seldver, W. W. Share, L. R. Shattuck, E. Skinner, G. C. Southard, G. A. Tibbals, S. G. Tibbals, W. L. Tyler, W. B. Vanderbilt, E. Van Dyck, G. J. Volckening, E. R. Von Nardroff, H. V. Walker; *Buffalo*, E. L. Ingram; *Cazenovia*, H. Burden, 2d; *Clifton*, F. R. Lord; *Clinton*, C. H. Smyth; *Flushing*, M. T. Bogert; *Laurel Hill*, W. C. Ferguson; *Locust Valley*, L. H. Vaile; *New Brighton*, A. Hollick, W. B. Johnson; *New Rochelle*, L. P. De Luze; *New York City*, F. E. Agramonte, S. W. Andrews, L. A. Ansbacher, A. Anthony, S. W. Balch, W. M. Baldwin, J. H. Banks, L. H. Barnett, G. S. Baxter, Chas. A. Bechstein, A. L. Beebe, W. L. Benedict, F. P. Benjamin, M. Benjamin, W. G. Berry, A. Black, E. M. Blake, O. Bodelsen, W. Boecklin, Jr., R. E. Booraem, R. C. Boyd, S. R. Bradley, N. L. Britton, H. D. Brewster, F. X. Brosnan, F. G. Brown, W. Bryce, C. R. Buckley, A. L. Burns, E. R. Bush, N. Butler, W. P. Butler, L. B. Cady, A. Calman, E. P. Casey, J. P. Carson, J. B. Cauldwell, C. F. Chandler, J. P. Channing, J. A. Church, Edmund Clark, G. H. Clark, C. E. Colby, S. B. Colt, G. B. Cornell, H. C. Cornwall, F. B. Crocker, A. R. Cushman, H. G. Darwin, C. H. Davis, J. W. Davis, J. A. Deghuee, A. F. Delafield, W. A. Dodsworth, C. F. Dolan, H. E. Donnelly, J. S. Douglas, I. W. Drummond, E. K. Dunham, B. H. Dutcher, W. G. Eberhardt, T. Egleston, A. H. Elliott, W. Elliott, I. N. Evans, G. E. Fahys, P. Le R. Fearn, C. F. Ferrer, H. Feuchtwanger, W. Fisher, F. W. Floyd, R. G. Foster, A. E. Foyé, J. W. Frank, W. H. Freedman, A. C. Gildersleeve, S. A. Goldschmidt, E. B. Gosling, L. P. Gratacap, A. D. Granger, J. L. Greenleaf, S. P. Griffin, L. N.

Gross, E. Gudeman, E. W. Guiterman, L. F. Haffen, A. W. Hale, R. W. Hall, A. P. Hallock, A. W. Hankinson, R. C. Hanson, G. E. Harding, O. B. Hébert, A. M. Heinsheimer, H. H. Hendricks, R. W. Hildreth, W. E. Hildreth, F. N. Holbrook, E. H. Holden, W. A. Hooker, F. F. Hunt, F. R. Hutton, O. Jackson, D. M. Jacobs, S. J. Jacobs, C. H. Joüet, C. P. Karr, J. C. Kastner, J. F. Kemp, G. T. Kirby, H. S. Kissam, E. C. Koch, J. J. Koen, W. B. Kunhardt, A. C. Langmuir, J. Lahey, R. Lahey, J. S. Langthorn, D. G. Leary, G. Leary, E. J. Lederle, A. R. Ledoux, A. L. Levy, E. W. Libaire, A. Liebmann, W. P. Little, A. R. Livingston, E. G. Love, L. McI. Luquer, T. T. P. Luquer, G. Lusk, C. F. McKenna, R. A. McKim, W. B. McKinlay, J. Maclay, H. T. MacKaye, A. S. Mahony, L. F. Massa, R. E. Mayer, C. S. McLoughlin, H. C. Mannheim, L. Marie, E. W. Martin, L. F. Massa, F. C. A. Meisel, J. H. Merritt, E. H. Messiter, H. H. B. Meyer, E. H. Miller, R. P. Miller, J. T. Monell, M. R. Montenegro, M. L. Mora, D. E. Moran, W. F. Morgan, G. W. Morris, R. K. Mosley, A. J. Moses, H. S. Munroe, C. E. Munsell, J. G. Murphy, K. Neftel, E. L. Newhouse, A. C. Nye, M. J. O'Connor, T. D. O'Connor, E. E. Olcott, Max Osterberg, F. N. Owen, A. McC. Parker, H. C. Parker, C. F. Parraga, Henry Parsons, W. B. Parsons, C. Q. Payne, Robert Peele, C. E. Pellew, C. P. Pengnet, Geo. Perrine, J. P. Pennington, W. Pistor, L. Pitkin, H. H. Porter, Jr., A. S. Post, A. V. Z. Post, W. E. Preston, J. C. F. Randolph, J. F. Randolph, R. Raynor, S. A. Reed, J. K. Rees, G. Renault, J. M. Rich, P. de P. Ricketts, T. W. Ridsdale, H. Ries, F. Roeser, O. L. Rogers, C. M. Rolker, R. G. Rood, A. Rosenthal, P. Rupp, F. M. Rutherford, F. Ruttman, E. E. Sage, F. A. Schermerhorn, W. J. Schiefflein, J. L. Schroeder, C. H. Schumann, J. G. Seligman, John Seward, F. D. Sherman, H. T. Shriver, F. M. Simonds, A. Smith, L. Smith, W. A. Smith, W. F. Smith, T. E. Snook, A. N. Spooner, J. H. Stewart, J. Struthers, W. H. Stuart, G. A. Suter, J. B. Taylor, H. C. Thompson, W. H. Titus, G. F. D. Trast, G. R. Tuska, A. H. Van Sinderin, E. Van Volkenburgh, H. T. Vulte, J. H. Wainwright, W. H. Weeks, H. McM. Welsh, J. S. C. Wells, William Y. Westervelt, R. D. White, T. G. White, H. P. Whitlock, F. G. Wiechmann, J. T. Williams, C. A. Wittmack, I. H. Woolson, E. L. Young; *Niagara Falls*, E. Z. Burns, W. S. Humbert; *Northport*, W. H. Ingersoll; *Ontario*, E. M. Parrot; *Oyster Bay*, D. Le R. Dresser; *Poughkeepsie*, A. E. Tower; *Rochester*, T. Nolan; *Rondout*, Edward Coykendall; *Sing Sing*, W. S. Page; *Skaneateles*, F. M. Thomas; *Spuyten Duyvil*, E. M. Johnson, G. H. Johnson, I. B. Johnson, L. B. Longacre; *Staten Island*, G. F. D. Trask; *Stirlengton*, Wm. Clark; *Syracuse*, H. B. Bellinger; *Tarrytown*, F. N. Holbrook; *Ticonderoga*, F. C. Hooper; *Tuxedo Park*, E. N. Van Cortlandt; *Utica*, G. W. Williams; *Westchester*, T. H. Harrington; *West Nyack*, S. O. Miller; *White Plains*,

R. E. Slade; *Whitestone*, W. J. Wallace, D. W. Ward; *Yonkers*, S. W. Balch, W. D. Horne.

North Carolina.—*Charlotte*, S. W. Cramer, G. B. Hanna; *Wilmington*, F. S. Clark.

Ohio.—*Cincinnati*, David Foerster, C. B. Going; *Cleveland*, R. F. Jopling, R. B. Watson; *Ivorydale*, J. P. Porter; *Marietta*, C. G. Slack; *Sandusky*, S. B. Newburg.

Pennsylvania.—*Allegheny*, G. H. Singer, L. Wertheimer; *Ambler*, E. Luttgen; *South Bethlehem*, A. L. Colby; *Chambersburg*, T. J. Brereton; *McKeesport*, T. Tonnelé, T. M. Hopke; *New Boston*, J. E. Jones; *New Castle*, E. L. Kurtz; *Osceola Mills*, G. McC. H. Good; *Philadelphia*, E. A. Congdon, S. M. Lillie; A. C. Munoz, Del Monte, Charles Piez, F. P. Smith, *Pittsburg*, J. S. Cox, R. G. G. Moldehnke, G. S. Page, C. A. Painter, G. E. Painter, G. Singer, Jr.; *Wilkesbarre*, Mac Dobbins, R. V. A. Norris; *Wyncote*, E. Luttgen.

Rhode Island.—*Providence*, Carl Barus.

South Carolina.—*Charleston*, P. E. Chazal

Tennessee.—*Gallatin*, A. J. Lamb.

Texas.—*Eagle Pass*, W. Hollis; *Shafter*, W. S. Noyes.

Utah.—*Jensen*, A. G. Johnson; *Sandy*, L. H. Norton; *Salt Lake City*, T. S. Mathis, R. H. Terhune, W. A. Wilson.

West Virginia.—*Franklin*, T. W. Osterheld.

Wisconsin.—*Hurley*, G. H. Abeel.

Wyoming.—*Evanston*, W. Newbrough; *Rawlins*, C. E. Blydenburgh.

Washington.—*Everett*, W. C. Butler; *Tacoma*, G. F. Milliken; *Seattle*, J. L. Warner.

OUT OF THE UNITED STATES.

AFRICA.

South Africa Republic.—*Johannesburg*, B. P. Carter, T. H. Leggett, H. C. Mannheim, F. M. Watern, E. A. Wiltsie.

AUSTRALIA.

New South Wales.—Randolph Adams.

EUROPE.

Italy.—*Rome*, S. J. Temple.

GREAT BRITAIN.

London.—C. M. Rolker.

NORTH AMERICA.

Canada.—*Golden*, S. S. Fowler; *Montreal*, C. E. Gudewill; *Nova Scotia*, *Londonderry*, C. A. Meissner; *Quebec*, R. D. Rhodes.

SOUTH AMERICA.

Brazil.—*Rio de Janeiro*, John Gordon.

Republic of Colombia.—*Medellin*, C. C. Restrepo; *Tumaco*, H. D. Conant, L. Whiting.

CENTRAL AMERICA.

Cuba.—*Clardenas*, D. L. Clark; *Cienfuegos*, A. C. Fowler; *Matanzas*, Y. Y. Polledo.

Guatemala.—*Quezaltenang*, J. F. Hawley.

Honduras.—*Tegucigalpa*, E. C. Fiallos.

Mexico.—*Chihuahua*, T. S. Austin; *City of Mexico*, V. M. Braschi; *Catalina Durango*, E. L. Dufourcq; *Corhuila*, Gomez Farias, Theo. Osterheld; *Sinaloa*, A. E. Swain; *Sierra Mojada*, E. Howe; *Tapachula Chiopas*, J. A. Navarro; *Concepcion del Oro*, A. W. Lilliendahl, F. A. Lilliendahl; *Hidalgo*, E. C. Van Blarcom; *Pachuca*, George T. Reckhart; *Zacatecas*, R. Yeizar.

CONSTITUTION

OF THE

ASSOCIATION OF THE ALUMNI

OF THE

SCHOOL OF MINES OF COLUMBIA COLLEGE.

INCORPORATED MAY, 1886.

ARTICLE I.

NAME.

THE name of this Association is "The Association of the Alumni of the School of Mines of Columbia College."

ARTICLE II.

OBJECT.

The object of this Association is to promote the professional welfare of its members, and to strengthen the bonds of professional and social fellowship among the Alumni of the School of Mines.

ARTICLE III.

MEMBERS.

SECTION 1. The membership in this Association shall be: I. Active. II. Associate. III. Honorary.

SEC. 2. All graduates of the School of Mines are eligible to active membership in this Association.

SEC. 3 Persons who have completed any of the special or graduate courses of the School of Mines are eligible to associate membership in this Association.

SEC. 4. Persons eminent in science who are or have been connected with the School of Mines are eligible to hononary membership in this Association.

SEC. 5. All members shall be elected by the Association upon proposal by the Board of Managers.

SEC. 6. Honorary and associate members shall have all the privileges of active members, except those of voting and holding office.

ARTICLE IV.

DUES.

SEC. 1. The annual dues of active and associate members of this Association shall be three dollars, payable in advance on the first day of October in each year. Honorary members shall not be required to pay dues.

SEC. 2. Any member not in arrears may become a life member, and be relieved from further payment of annual dues by the payment, at any one time, of fifty dollars.

SEC. 3. Members one year in arrears may, after due notification, be dropped from the roll, by vote of the Board of Managers, and shall then forfeit their rights and privileges in the Association until all arrears are paid, or until reinstated by the Board.

SEC. 4. Only those members not in arrears shall be entitled to vote or hold office.

ARTICLE V.

OFFICERS AND MANAGERS.

SEC. 1. The officers of the Association shall be a President, a Vice-President, a Treasurer and a Secretary. These officers and eight managers, to be elected as hereinafter provided, shall constitute the Board of Managers.

SEC. 2. The President, Vice-President, Treasurer and Secretary shall hold office for one year, and are eligible for re-election. The Managers shall hold office for two years, and are not eligible for re-election until one year after the expiration of their terms.

ARTICLE VI.

ELECTION OF OFFICERS AND MANAGERS.

SEC. 1. Before the last day of June of each year the President shall appoint a committee of five active members to nominate for election by the Association for the ensuing year a President, a Vice-President, a Treasurer, a Secretary and four Managers.

SEC. 2. The Nominating Committee must send in the nominations to the Secretary not later than October 15th of each year, and such nominations shall be distributed at once to the active members in the form of letter ballots, which must be signed and forwarded to the Secretary, and opened and counted by tellers at the annual meeting of the Association.

SEC. 3. The officers and managers must be residents of New York city or vicinity, and the four managers shall be selected, one from each of the four groups into which the Board of Managers shall, at its first meeting in each year, divide in chronological order the classes which have graduated from the School of Mines.

ARTICLE VII.

THE BOARD OF MANAGERS.

SEC. 1. The Board of Managers shall have the management of the affairs, funds and property of the Association, and it shall be the duty of the Board to see that the purposes of the Association are carried out according to its Constitution and By-Laws.

SEC. 2. The Board of Managers shall hold at least four regular meetings during each year, namely, in the months of January, May, October, and December. Other meetings shall be called by the President as may be required.

SEC. 3. The Board shall have power to fill any vacancy in its body by the election of an active member of the Association from the group in which such vacancy occurs.

SEC. 4. A quorum shall consist of a majority of the whole Board.

ARTICLE VIII.

PRESIDENT.

It shall be the duty of the President to call and preside at all meetings of the Board of Managers and of the Association; to appoint such standing and other committees of the Association as may be found necessary or convenient for the conduct of its work, and to perform such other duties as may develop upon him by virtue of his office.

ARTICLE IX.

TREASURER.

It shall be the duty of the Treasurer to collect and have custody of all moneys and pay all bills of the Association, but no indebtedness shall be incurred unless approved by the Board of Managers. No bill shall be paid unless previously endorsed by the Secretary. The Treasurer shall present to the Board of Managers a written report upon the financial condition of the Associa-

tion at the annual meeting in December. His accounts shall be audited by a committee of the Association appointed at the annual meeting.

ARTICLE X.

SECRETARY.

It shall be the duty of the Secretary to issue notices for all meetings of the Board of Managers and of the Association, to keep minutes of all meetings, to record the names, addresses, and professional occupations of the members, and to perform such other duties as may be assigned to him by the Board of Managers.

ARTICLE XI.

DELEGATES TO UNIVERSITY ALUMNI COUNCIL.

This Association shall be represented in the University Alumni Council of Columbia University by delegates appointed by the Board of Managers, under such conditions and in such manner as the said Board shall prescribe.

ARTICLE XII.

MEETINGS.

SECTION 1. The annual meeting of the Association shall be held in the last week of December in each year, unless otherwise ordered by the Board of Managers.

SEC. 2. Regular meetings of the Association for social intercourse, or for the discussion of subjects of general or of professional interest, shall be held in the city of New York at such time and place as may be directed by the Board of Managers.

SEC. 3. Upon the written request of not less than ten active members, the President shall call a special meeting of the Association, which request, as also the notice of any special meeting, shall state the object for which the meeting is called.

SEC. 4. A quorum shall consist of thirty active members of the Association.

ARTICLE XIII.

SUSPENSION OR EXPULSION.

Any member of the Association may be suspended or expelled for misconduct in his relations to this Association or in his profes-

sion on proof thereof in such manner as may be prescribed hereafter by By-Laws.

ARTICLE XIV.

All interest in the property of the Association of persons resigning or otherwise ceasing to be members shall vest in the Association.

ARTICLE XV.

AMENDMENTS.

Any amendment to the Constitution must first be submitted in writing to the Board of Managers, and must be approved hy a vote of two-thirds of the whole Board before presentation to the Association. Due notice of any proposed amendment shall be sent by the Board of Managers to every active member of the Association at least one month previous to the meeting at which such amendment is to be voted upon. A three-fourths vote of the members voting, in person or by letter ballot, shall be necessary for the adoption of such proposed amendment.

BY-LAWS.

I. Unless otherwise directed the Order of Business at any meeting of the Association and its Board of Managers shall be as follows:

1. Reading of minutes of preceding meetings and action thereupon.
2. Report of the Board of Managers.
3. Reports of officers.
4. Reports of standing committees.
5. Reports of special committees.
6. Elections and announcement of elections.
7. Unfinished business.
8. New business.
9. Appointment of committees.
10. Adjournment.

II. The absence of any member of the Board of Managers from two consecutive meetings of the same, of which he shall have been regularly notified, shall be considered as a resignation on the part of such member, unless the Board shall excuse such absence. The

vacancy thus created shall be filled as provided for in the Constitution.

III. The Standing Committees of the Board of Managers shall be as follows:

1. On School of Mines Quarterly.
2. On Badges.
3. On Meetings of the Association.
4. Of Conference with the Columbia College Alumni Association, and such other Committees as may be necessary.

All such committees shall, at the expiration of their terms of office, present written reports to the Board of Managers.

IV. The official organ of this Association shall be the SCHOOL OF MINES' QUARTERLY, which will be furnished to all active and associate members.

V. The Standing Committee on Meetings shall arrange for regular meetings of the Association in October and March of each year unless otherwise ordered by the Board of Managers.

VI. These By-Laws may be amended at any regular meeting of the Association, but only by a vote of two-thirds of those present, and provided that ten days' notice in writing of the proposed amendment shall have been given to the Board of Managers, and also that notice of the same shall have been given by the Secretary in the call for the meeting.

SERIAL

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vol. 17, 1895-96

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